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U. S. DEPARTMENT OF AGRICULTURE.
DIVISION OF ENTOMOLOGY.
BULLETIN NO. 27.

REPORTS

ON THE

DAMAGE BY DESTRUCTIVE LOCUSTS

DURING

THE SEASON OF 1891.

MADE UNDER THE DIRECTION OF THE ENTOMOLOGIST.

PUBLISHED BY AUTHORITY OF
THE SECRETARY OF AGRICULTURE.

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF ENTOMOLOGY,
Washington, D. C., January 19, 1892.

SIR: I have the honor to transmit, for publication as Bulletin No. 27 of this Division, the following reports by three of the field agents of the Division on the damage done by destructive locusts during the season of 1891.

Respectfully,

C. V. RILEY,
Entomologist.

Hon. J. M. RUSK,
Secretary of Agriculture.

DAMAGE BY DESTRUCTIVE LOCUSTS.

INTRODUCTION.

The season of 1891 was marked by widespread alarm felt at the presence in force of several species of destructive locusts in different parts of the country, and particularly in the Western States. A general summary of these incursions was given in my annual report for 1891, and in this bulletin are brought together the detailed reports of the agents who were sent into the field and who carefully examined the country from which locusts were reported.

Mr. Bruner visited portions of Colorado, Wyoming, the Dakotas, Minnesota, Montana, Idaho, and Utah, and also made a short trip into Manitoba; Mr. Coquillett confined his investigations to the State of California, while Professor Osborn visited the State of Kansas only.

In addition to the localities reported upon in this bulletin Mr. Banks visited Texas and New Mexico, but as his report was negative in character it need not be printed here. Professor Osborn's report has previously been printed in INSECT LIFE, Volume IV, pp. 49 to 56. It will be noticed that Mr. Bruner, in speaking of the species which I have always placed in the genus Caloptenus, refers to them under the genus Melanoplus. The question as to the value of Melanoplus as a genus is discussed in the first report of the U. S. Entomological Commission, and I prefer to hold to the older name. It will suffice, however, for the reader of this bulletin to know that the name Melanoplus as used by Mr. Bruner is synonymous with Caloptenus as used by me.

C. V. R.

REPORT ON DESTRUCTIVE LOCUSTS.

By Lawrence Bruner, *Special Agent.*

LETTER OF SUBMITTAL.

Lincoln, Nebr., *October 3, 1891.*

Sir: I beg to submit herewith a report of my observations on the destructive locusts of the country during the current year, a work which has engaged, as you already know, the greater portion of my time during the past summer. While occupied with these investigations portions of Colorado, Wyoming, the Dakotas, Minnesota, Montana, Idaho, and Utah, along with the Red River Valley of Manitoba, were visited by me. In addition to the regions personally examined, I am also enabled to include reports on other districts based upon reports and specimens obtained from friends who themselves had examined into the conditions of these affairs. It will not seem surprising, therefore, if the greater portion of my report relates to this particular group of insects. Since there have been a number of species of these destructive locusts concerned in the injuries inflicted in various portions of the country during the season, I have thought it best not only to mention all of these, but also to include such others as have been recorded as pests during former years, as well as those that are liable in the future to become injurious over local areas. This report can then serve as a sort of reference hereafter for those wishing to study the injurious insects of this class found in America north of Mexico.

It is but just here to acknowledge the aid which I have received from various railroad companies that took sufficient interest in the locust question to grant it, in the shape of transportation by which I was enabled to visit many regions that would not otherwise have been reached. I would also extend my thanks to all those persons who have aided me in any manner whatsoever during the summer's work among the destructive locusts.

The regions visited by myself and other agents of the Division early in the season, as well as those examined by Messrs. Snow and Popenoe, of Kansas, have been reported upon heretofore; hence will not be treated at length here. The district comprised in North Dakota and Minnesota, over which the true Migratory or Rocky Mountain Locust was more or less abundant, has been carefully studied during the year by Prof. C. B. Waldron in the former and Prof. Otto Lugger in the latter State. The reports of these gentlemen are appended hereto.

Very respectfully yours,

Lawrence Bruner.

Prof. C. V. Riley,
U. S. Entomologist.

About the middle of June reports of damage by grasshoppers or locusts began to make their appearance in the papers of the country at large, and especially were such reports of frequent occurrence and of an alarming nature in the region where the Rocky Mountain locust ravaged the country some years ago. Nor were these reports purely rumor, for it was definitely known to entomologists and others that numbers of these insects had hatched in various parts of the country and were at this time devouring the vegetation at an alarming rate. The past few years had also been very favorable to their increase, while considerable injury to crops had actually been done by these insects during last year. In Colorado railroad trains had been stopped by the insects which gathered upon the rails and were crushed by the heavy wheels of the locomotives. From Idaho and California came reports of grasshopper swarms, and in portions of Minnesota and North Dakota these insects were known to occur in numbers too great for the settlers to be troubled with visions of overflowing granaries. Accordingly, quite early in July the Secretary of Agriculture decided upon a general tour of inspection by specialists in insect study, who were to work under the direction of Prof. C. V. Riley, the United States Entomologist. Several field agents located in different parts of the Union were immediately instructed to examine into the reports emanating from adjacent localities, and to report the results of such investigations promptly.

Having been more or less constantly engaged in the special study of this particular group of insects for the past ten or eleven years, the writer was instructed to make a general tour of inspection over the region known as the range of the Rocky Mountain or Migratory Locust. During the time occupied in carrying out these instructions portions of Colorado, Wyoming, Montana, North Dakota, Minnesota, Manitoba, Idaho, and Utah were traversed. The following reports will give some idea of the results of these various regions visited:

THE LOCUST PEST IN COLORADO.

The first locality which I visited for the purpose of studying these destructive locusts was located in eastern Colorado upon the plains in the vicinity of the town of Akron, on the line of the Burlington and Missouri River Railroad. Here it was found that a large, long-winged locust, which is known scientifically by the name of *Dissosteira longipennis* Thos., was the culprit, and that it was really destroying the grasses on the prairies over an area of fully 400 square miles of territory. A little investigation showed it to be the same species that was present farther to the southward, and that had been the cause of the newspaper reports which filled the columns of the dailies at the time. By driving northward from Akron across the country to the Platte River, other small detached swarms of the same locust were encountered, and judging from such reports as were obtainable at Sterling,

this insect also occurred in destructive numbers in several limited localities of southeastern Wyoming.

At about the same time that I was investigating the northern border of the region occupied by the Long-winged Locust, Messrs. Snow and Popenoe, of Kansas, were studying it along its southern limits, where they found the insect in even much greater numbers than I did along its northern limits of abundance. As those gentlemen have made a much more thorough investigation of the pest than I have, and have written a rather full report of the results of their labors, the readers are referred to that paper if they desire to obtain the full particulars.

The description, habits, distribution, and life-history of this species will be given further on in this report, in connection with like particulars in reference to other species of these destructive insects which occur in North America north of the Mexican boundary.

THE LOCUST PEST IN THE RED RIVER VALLEY OF NORTH DAKOTA, MINNESOTA, AND MANITOBA.

After returning to Lincoln from this Colorado trip, the Red River Valley of North Dakota, Minnesota, and Manitoba was visited. In this latter region it was reported that the genuine Rocky Mountain Locust (*Melanoplus spretus*) was doing some injury to grain. Upon arriving at St. Anthony Park, where I expected to find the Entomologist of the Minnesota Experiment Station, it was found that that gentleman was away from home among the grasshoppers in the northern part of his State. The next halt was made at Fargo, N. Dak., where my letter of instructions suggested that I had better stop and confer with the officials of the experiment station located here, since they were more apt to be familiar with the locust question so far as their State was concerned than would anyone else. Here also I found that most of the station workers were away from home engaged in active work against the locust pest.

By lingering in the vicinity for a few days, and occupying my time in making collections of such species of locusts as were to be found about the college, I was enabled to leave at least twenty species of authentically labeled specimens with the authorities when they returned a few days later. Afterwards a number of infested localities were visited in company with Prof. C. B. Waldron, who had chief charge of the locust work in this State. These short journeys over the region sufficed to show conclusively that not only was the true Migratory Locust present, but also three other species, all engaged in the injuries to crops in the region under consideration. Here then, in the Red River Valley and for some distance back into the "hills" to the westward, were four distinct species of locusts present in unusually large numbers, while, in addition to these, a number of other species were by no means rare. A journey as far north as Winnipeg, in the province of Manitoba, showed that this region of undue increase among these various locusts also extended into that country for some miles be-

yond the point reached. Not having the authority to proceed, I was unable to determine the exact boundary of this region; but from what I was able to learn through inquiry among the intelligent inhabitants, it was surmised that at least one-half of the province was to be included within that boundary. Of course I do not wish to be understood that every portion of the territory thus included was covered by the pest, for such was not the case. The hoppers occurred in spots in Manitoba just as they did in Minnesota and North Dakota. I found that this region contained the following species of locusts in hurtful numbers: the Rocky Mountain or true Migratory (*Melanoplus spretus*), the Lesser Migratory (*Melanoplus atlanis*), the Two-striped Locust (*Melanoplus bivittatus*), and the Pellucid Locust (*Camnula pellucida*).

Further inquiry resulted in showing that the Rocky Mountain species had entered North Dakota during the previous fall from the northwest, dropping into the State at a point just east of the Turtle Mountains, and leaving the first batch of eggs near the town of Cando in Tower County. From here they evidently passed eastward and a little to the south, leaving eggs at various points along the route wherever the conditions were favorable.

It is quite probable that these locusts which entered the country last fall were those that had hatched in spring in the vicinity of Regina and disappeared from that region in a southeasterly direction after becoming fledged. Should this be the case, there are now no other swarms of this particular locust in the United States and British America that we know of, nor does the species appear to be even common in other localities; hence the importance of extra efforts on the part of all interested parties at this particular time to stamp out the pest where it occurs at present. We can easily afford to be without it, for, as the succeeding pages will show, we have plenty of other locusts that are apt to occupy our attention during almost any year in the future. That any of these destructive locusts can be successfully fought and their injuries prevented has been pretty well demonstrated time and again. At no time, however, has this been so plainly shown as during the past spring and summer in this very region in question. This comparative ease with which the insect was handled here is chiefly due to its habit of egg-laying varying somewhat in the Red River Valley from what it is known to be in other parts of the country where it has been studied.

The attached reports of Messrs. Lugger and Waldron, who have been in the region and who had under their direction nearly all of the warfare already mentioned, will best serve to show the *modus operandi* followed and the results secured. Careful estimates have been made as to the actual benefits to be derived from fighting these destructive grasshoppers, and the figures obtained are really surprising. It is supposed that at least calculation 20,000 acres of wheat alone were saved which otherwise would have been destroyed by the locusts that

were killed before and after hatching. This wheat, at 30 bushels to the acre, an average yield for the twelve counties where the locust plague occurred, would be worth about $400,000. The actual outlay in money by the authorities, State and county, for machinery and oil could not have been more than $1 for each $50 saved. We were told that in the two States together there were over 200 "hopper-dozers" at work collecting and destroying the locusts. These machines were kept going for fully two weeks, some of them longer, and each machine caught from 4 to 11 bushels of the locusts per day. It is supposed that fully as many as 8,000 to 10,000 bushels were thus destroyed, many of them being quite small and hence counted for more. At any rate, the destruction was great. An equal number were destroyed by plowing the eggs under prior to their hatching. These figures represent an actual present saving; but what shall we say about the probable future saving to the settlers of these two States and of those adjoining, had none of this work of destruction been carried on? With favoring conditions in climate and surroundings nearly all of our various species are capable of increasing at the ratio of fifty-fold; *i. e.*, each female will lay upwards of 100 eggs. About one-half of the young hatched from these eggs will be males and the other half females. Therefore, if twelve counties are overrun with these insects this year, and they all live to deposit eggs, with all favoring circumstances the result will be sufficient hoppers by the following year to overrun fifty times twelve counties, or six hundred counties, a matter too formidable to think of.

Since I have already reported to you the results of this trip through the Red River Valley, and also spoken of it at the Washington meeting of the Association of Economic Entomologists, I will not enter farther into details here. Suffice it to say, that after going over the regions already indicated, I went west over the line of the Great Northern Railroad to Helena, Mont., stopping off at convenient points along the road. At these places inquiries were made among the settlers concerning locust abundance, besides going out into the country and examining for myself to make doubly sure that there were no migratory locusts in the entire country west of Devil's Lake in North Dakota. Only at several points in the mountains of Montana did I find these insects at all abundant, and there only over very limited areas where the *Camnula pellucida* occurred in the valleys, in hay fields.

PROF. WALDRON'S REPORT.

FARGO, N. DAK., *Aug. 6, 1891.*

DEAR SIR: In compliance with your request, I submit the following report concerning the recent appearance of grasshoppers in North Dakota.

The first report of grasshoppers came from Orr, a station in the northern part of Grand Forks County. The report was received July * 25, and on July 26 I went to the infested region and found a considerable number of grasshoppers, the oldest of which had been hatched two or three weeks before, while new ones were appearing

*This must be a mistake, and I think should read May 25 instead.—L. B.

constantly. The two prevailing species were the *Caloptenus spretus* and the *Caloptenus atlanis*. The former species was the most numerous, the ratio being about 4 to 1. Other species existed, but as they were found but sparingly no attempt was made to enumerate them.

As was to be supposed, the hatching was confined entirely to the stubble fields. From these the young insects moved forward onto the adjacent wheat fields, and at the time of my first visit a narrow strip of grain along a few of the fields had been destroyed. The usual methods of extermination were resorted to, *i. e.*, the plowing of the adjacent stubble fields and the use of hopper-dozers along the edges of the infested fields.

The Great Northern Railway immediately plowed all of its lands in which the grasshoppers were hatching, and, so far as it was possible, most of the farmers did the same. The beneficial effect of the plowing was very marked even after the process of hatching was well advanced.

The work of the coal-tar and kerosene hopper-dozers was also very effective, each pan catching from 5 to 8 bushels per day. The canvas traps, such as were reported as giving more or less satisfactory results elsewhere, were abandoned after the first one or two trials. When canvas traps are used the grasshoppers have to be caught twice, and the second operation—that of securing them after they have jumped into the bag—is the more difficult one; so difficult, in fact, as to border on the impossible.

While working at Orr reports came in from the adjoining regions, showing that the infested region reached as far north as the center of Walsh County, nearly as far south as Larimore, and occupied a region some 10 miles wide. The grasshoppers did not cover the entire region, but were found in patches here and there, more noticeably in the vicinity of Park River, Conway, and Inkster, with a few at McCanna and Niagara. They were also found through the central part of Nelson County, though not in destructive numbers.

Grasshoppers were also found to some extent in the western part of Ramsey County, at a place called Church's Ferry, and north from there 18 miles, at Cando. In all of the places mentioned the Rocky Mountain Locust was the prevailing kind. A few of this species, associated with many others, chiefly the *Caloptenus bivittatus*, were found at Clifford, in the western part of Trail County. The Rocky Mountain Locust was also reported from the central part of Ransom County, but as they were few in number the locality was not visited. The work of extermination was carried on in all parts of the State in which the grasshoppers appeared in sufficient numbers. While the damage to this year's crop would not have been great in any event, yet the warfare in many localities has no doubt resulted in a larger crop than would otherwise have been harvested.

Our chief concern is for the coming year. I shall stay in the infested localities for the remainder of the season, carefully noting in what regions, if any, the eggs are laid, so that we may carry on the work of future extermination intelligently and thoroughly.

C. B. Waldron.

Mr. Lawrence Bruner,
Lincoln, Nebr.

I add still further matter in reference to this outbreak of locusts in North Dakota in the shape of a special bulletin, which was issued from the Agricultural Experiment Station of that State early in July. This bulletin was prepared conjointly by the Director, Dr. H. E. Stockbridge, and Prof. C. B. Waldron, whose report is already given. This special bulletin is not large, hence will be copied in full.

INTRODUCTION.

(By H. E. Stockbridge.)

On June 19 the Director of the North Dakota Experiment Station received a telegram from Superintendent Jenks, of the Dakota division of the Great Northern Railroad, dated Larimore, announcing the presence of grasshoppers in overwhelming numbers in the vicinity of Orr, Grand Forks County, and requesting assistance and advice in the premises. Professor Waldron, of the station staff, under instructions, left for the scene of the outbreak on the first train leaving Fargo after the announcement was received, and June 20 returned with specimens of the locusts and full particulars concerning the presence, numbers, and amount of devastation wrought, gathered by personal inspection in the field. After further consultation, Professor Waldron immediately returned to Orr, with full instructions and authority to take any steps or action necessary and incur any legitimate expense required for the suppression of the outbreak and extermination of the pest coming properly within the sphere or jurisdiction of the station.

Meanwhile communications had been received from the Commissioner of Agriculture, the Commissioners of Grand Forks County, and several interviews had been held with the Governor of the State looking toward control of conditions and prevention of ravage.

On June 25 the increased presence of the pest and its extension to other localities seemed to demand more stringent measures for suppression, and after a thorough inspection of the infected localities in Grand Forks County, and a consultation, by request, with the township commissioners of the infected townships, it was decided that a more extended use of the hopper-dozer and the plowing of large areas of stubble must be immediately instituted. The use of the dozer was easily accomplished. Twelve of these implements were immediately ordered and put to their work of execution, while a further and large shipment of coal tar was ordered by telegraph. The land-owners in the interested localities seemed to recognize the emergency, and manifested a willingness to do everything in their power toward exterminating the enemy. A great difficulty, however, lay in the impossibility of plowing with pasture-fed horses, and the impossibility, in many cases, of procuring grain or feed on individual responsibility, while the ownership of stubble by non-residents was a further obstacle to the immediate plowing of such land, and thus exterminating their grasshopper denizens. On returning to Grand Forks the Governor of the State, the resident county commissioner, Commissioner of Agriculture Helgesen, Professor Waldron, and the director of the station immediately held an interview, in which the exigencies of the occasion were fully discussed and further measures of control instituted. Feed was immediately shipped to the infested localities on the responsibility of the county commissioners. The general authority of the State in the premises, so far as active measures were concerned, was placed in the hands of the Commissioner of Agriculture, while immediate supervision of disbursements was intrusted to resident county commissioners. Professor Waldron, on behalf of the experiment station, was instructed to remain in the field, visit every new locality of outbreak, and furnish all advice and assistance possible in the premises, remaining in personal control of the means of suppression at Orr and Inkster, which localities would serve for experimental purposes and as illustrations of restrictive measures for the benefit of other communities. At present areas of limited infection exist in Grand Forks, Walsh, Nelson, Towner, and Ramsey counties, the region of chief infection being along the Park River branch of the Great Northern Railroad for a distance of nearly 40 miles between Larimore and Park River, and it is here the only real damage has been wrought and the chief cause of apprehension lies. It is now confidently believed that with the vigorous measures adopted serious damage during the present season is not to be anticipated. The danger lies in apathy on the part of the public, which may result in the survival of a sufficient number of the mature insects to

lay the eggs of broods from which serious damage to next year's crops may follow, and it is with a view to prevent this contingency that the present information is placed at the disposal of the public. The measures for prevention are briefly, but fully, explained in the present bulletin, the material for which has been chiefly prepared by Prof. Waldron, perfectly familiar with the premises from actual personal experience. The measures recommended are simple, easily followed, and so cheap and effective that no excuse can be found for a failure to heed the warning and follow the suggestions offered. Further than this, it should be borne in mind that plowing, the chief dependence for prevention of the locust plague, has other advantages in the way of soil improvement and suppression of weeds which must fully compensate for any outlay required.

THE ROCKY MOUNTAIN LOCUST

(By C. B. Waldron.)

The habits of the locust are well known, and measures for their complete destruction are so cheap and simple that they can be carried out by simply varying the agricultural methods now practiced and not adding materially to their expense. No attempt will be made in this bulletin to give more of the habits and natural history of the locust than is absolutely required in dealing with the problem of extermination.

The eggs in the region named were doubtless laid during the latter part of August by locusts coming over from Manitoba and perhaps from Minnesota. Flights of the insects that were passing towards the regions now infested were observed on the 20th of August. The eggs were laid in stubble fields, as would have been supposed from our former knowledge of the habits of the locust and as subsequent investigation proved. If the presence of the locusts last season had been properly reported measures would have been adopted that, with no financial outlay, would have absolutely prevented the reappearance of the pest.

It has been found by repeated trials, particularly in Minnesota, that if the eggs of the locust are covered with 4 or 5 inches of moist earth, or 6 inches of dry earth, the hatching will either be prevented or the young will die before being able to reach the surface. It follows, then, that we may completely destroy the egg by plowing the fields in which they are laid, either in autumn or before the middle of June, at which time the hatching begins in this latitude. As the eggs are never laid in thick sod nor in loosely plowed earth it will be seen that plowing need not extend to any land except the stubble fields. If all the stubble land is put to wheat in the regular manner, the plowing to be done either in fall or spring, no word of complaint will come because of grasshoppers. If summer fallowing is adopted the plowing should be done in May or early June, and the land may be plowed again in the fall if considered necessary. This method of fallowing, if followed from the start, has the added advantage of destroying such weed pests as the Pepper Grass, "French Weed," etc.

Even if the plowing is not finished before hatching begins, it should be kept up until the stubble fields are all turned over. The period of hatching begins about June 1, or later if the land is lower, and continues about six weeks.

When the young grasshoppers are first hatched they are covered with a little sac, and by it enabled to push up through 2 or 3 inches of earth. If the grasshoppers are covered with earth after the sac disappears, from 1 to 2 inches is sufficient to kill them. One reason for continuing the plowing, then, is to bury and kill what insects may already be hatched. Even the grasshoppers that are not plowed under will be very apt to starve before escaping from the plowed land. As a rule it will be found well to plow a strip 5 or 10 rods wide right around the stubble field to retain

the grasshoppers inside, and then the rest of the field may be plowed in the usual manner. The insects will be driven toward the center of each land as the plowing proceeds. and the last furrows will be found to cover up great numbers, especially if plowed late in the evening or as soon as it becomes daylight in the morning.

If thought best, the plowing may not be finished at once, but a strip left in the middle of each land on which the grasshoppers may be caught, or the strip may be covered with dry straw and the insects destroyed by burning. Plowing the stubble field is an important step in fighting the locust in case much grass is found growing in the stubble. If the stubble is left standing the grasshoppers will be slow to leave their hatching ground if the food is abundant, and thus for several weeks the insects will be passing from the stubble to the wheat fields. The task of catching them is much shorter after the fields are plowed. In catching the locust several means have been employed at various times and places, but we will now describe only one, that being the one that from its cheapness, ease of obtaining and operating, and general efficency, seems to be best.

The apparatus referred to is the tar pan or hopper-dozer. The pan should be made of rather heavy sheet iron or ordinary galvanized iron. The length should be about 16 feet, width of bottom from 2½ to 3 feet, and the back about 2 feet high. The back may be made higher by a strip of gunny-cloth or a board, if experience shows the necessity. Along the front edge of the pan is placed a board from 1 to 2 inches thick and 4 inches wide. This is beveled on the lower front corner, so that the pan may pass easily over obstructions, and the iron that constitutes the bottom of the pan is brought around the front edge of this strip and nailed on top. The pan is further strengthened by a strip of timber along the back. The ends are of 1½ inch plank, each bearing a clevis at the front for drawing the pan. The pan is drawn by two horses, one hitched in front of each end, on a rope about 10 feet long. Fastened to these ropes by a strong cord is a 16 foot pole so arranged as to drag about a foot in front of the pan so as to scare up the grasshoppers.

The pan is heavily smeared with coal tar, thus catching and holding all insects that jump in. It is a good plan to add a small amount of kerosene to the coal tar, so that the locusts may die almost as soon as entering the pan. Ordinary observation will enable a person to see when the insects should be scraped out and a fresh supply of tar added. The most effective time of day for using the dozer is toward evening when the insects are feeding. A pan working in this manner will catch several bushels a day in regions that are badly infested.

SIR: I have just returned from my canvass of the grasshopper region and find the situation to be as follows:

In general there appears to have been more or less egg laying over the whole region outlined in my former report to you. From Orr north to Park River this condition was modified largely by the presence of what I took to be a dipterous parasite, though I saw nothing but the larval form of this parasite and can not tell positively what it is. The larva was about one-fourth of an inch long and turned from white to a light brown on emerging from its host. In certain localities fully three-fourths of the *Caloptenus spretus* and *C. atlanis* were destroyed by the timely ravages of this parasite, but the *C. bivittatus* seemed to escape its attacks. In the vicinity of Larimore the parasite appeared but little. The region in which the greatest number of eggs is deposited is the southern part of Towner County in the vicinity of Cando. The *C. spretus* was abundant here and stayed till very late with no trace of parasites. The same condition exists all over Benson and Ramsey counties though in these last-named regions the grasshoppers themselves were far less numerous. The gospel of plowing has been so thoroughly preached that little danger may be expected except in what

may be called the outskirts of the grasshopper region, *i. e.* the western part of Walsh County, the southern part of Cavalier, and the northern half of Ramsey County. In these places many of the farms have been deserted and the chance for extermination thereby lessened.

Very truly yours,

C. B. WALDRON.

MIGRATORY LOCUSTS IN MINNESOTA IN 1891.*

(By Otto Lugger.)

The year 1891 has been remarkable, as far as insects are concerned, for a multitude of very noxious insects. Species, in former years rather uncommon, have appeared in vast numbers, causing more or less alarm on that account. A number of reasons may be given for such a state of affairs; but the present bulletin is not the proper place to discuss them. The chief causes may, however, be stated to be exceptionally mild winters and uniformly favorable growing seasons.

Among the numerous injurious insects of 1891 none are more dangerous than the various species of locusts or grasshoppers. Besides the native species, which in seasons favorable to locusts are always more or less injurious, we have to deal at present with three kinds of migratory locusts, *i. e.:* Rocky Mountain Locust (*Melanoplus spretus*, Thos.), Lesser Migratory Locust (*Melanoplus atlanis*, Riley), Pellucid Locust (*Camnula pellucida*, Scudd.).

In the report of the Entomologist to the Board of Regents, published in the Biennial Report for 1890, page 17, the following statement was made:

"But the danger of fresh invasion remains, and it is in the line of wise legislation to take time by the forelock, and provide the necessary means for suppressing another outbreak. The Rocky Mountain Locusts are becoming very numerous in their native breeding places, and have already produced some swarms extending beyond their usual haunts. In fact a large swarm of locusts passed on August 14, 1890, over Crookston, flying in a southeasterly direction. It is true the few mutilated specimens received by the Entomologist indicated three native species, but this material was insufficient to furnish proof that the 'Hateful Grasshopper' was not a member of this swarm. Through the kindness of the St. Paul, Minneapolis and Manitoba Railroad, the Entomologist was enabled to inquire into this matter, and found that this swarm had continued its flight from Crookston over Fosston, and had landed near to and in the upper Rice Lake, in the White Earth Indian Reservation, where the great majority of the insects composing this swarm perished. Some eggs were deposited near Crookston, and especial attention should be paid to the locusts resulting from them; but it could not be learned that others had been laid elsewhere. It will be very wise to recollect that the number of locusts in their home have reached the danger mark, and may, if favored by a suitable season, become not simply a menace but a reality."

After the publication of that report more material was received, which proved beyond doubt that the swarm entering the Red River Valley was composed mainly of migratory species. But even without such additional proofs it was quite certain that we had to deal with migratory species, as all our native ones, not being able to make extended flights, could not form such large swarms. Notwithstanding the evidence and warning of danger, no preventive measures were adopted and the intruders were allowed to settle in the invaded region.

Early in June a number of newspapers published complaints that locusts were doing considerable damage in some fields, but mainly near Pelican Rapids, Otter Tail County. A visit to that region indicated that a small swarm of locusts had deposited their eggs in that locality, but that timely work would suffice to kill all the

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*Reprinted from Bulletin No. 17, Minnesota Agricultural Experiment Station.

young insects, as they were small at that time. The species found at Pelican Rapids was the Lesser Migratory Locust, reënforced by very numerous specimens of the two-striped species. No real Rocky Mountain Locust could be found. Later reports of damages caused by locusts in various parts of the Red River Valley reached his excellency Governor W. R. Merriam, who requested me to proceed at once to the infested region, and to do all that could be done at the time to prevent another outbreak of a locust plague. The Governor also instructed the county commissioners in the infested region to do all that could be done to stamp out the locusts in their respective counties.

When I reached the Red River Valley it was almost too late in the season to perform real effective work, as the great majority of these injurious insects had already acquired wings. Near Crookston, Polk County, the chairman of the county commissioners, Mr. Kirsch, had already commenced operations, and had done some very good work, both by plowing infested fields and by poisoning the grain growing upon adjoining ones. In fact, in several cases he had killed the insects to such an extent that but very few escaped. If his example had been followed everywhere the majority of the dangerous kinds of locusts would have been killed; but owing to a belief that the species found in such numbers was only a harmless one, few farmers adopted his methods, while many others even ridiculed the idea of having any migratory insects in the county at all. It is rather peculiar what strange freaks memory will play in some cases. Among others some farmers who had passed through former grasshopper troubles claimed that the Rocky Mountain Locusts were insects fully 2, 3, or even 4 inches in length, and that moreover were provided with six wings.

As soon as possible a large number of hopper-dozers were constructed and were distributed by County Commissioner Kirsch to all farmers who wished to use them. Both hopper-dozers and kerosene oil were furnished free by the county, and many farmers set to work to kill as many of the intruders as possible. The insects, being already winged and very active, could no longer be caught during the day; but towards evening, when they crawl to the highest points of the plant to escape the chilling effect of the moist soil, the machines proved of great value and immense numbers of locusts were killed. Various modifications of the hopper-dozers were used to suit the varying conditions of the fields and of the crops. Other intelligent farmers and merchants living in the counties of Marshall, and Kittson obtained models of these machines and commenced in earnest to destroy their enemy.

A close inspection of the invaded region showed that the sandy ridge running north and south through the counties of Polk, Marshall, and Kittson was more or less infested in spots. Without any exception locusts were found only in fields that had been plowed in July and August, 1890, or before the invading insects had deposited their eggs. In no case were locusts found in the native prairie nor in any soil that had been plowed late in fall or early in spring. These observations coincide exactly with those made a few years ago in Otter Tail County and indicate very plainly how to prevent locusts from causing injury in 1892. This inspection also showed that we have to deal not alone with one kind of migratory locusts, but with two other species equally injurious. Near Crookston the Lesser Migratory species is the most common one, but farther north the Rocky Mountain Locust becomes more numerous, and in the extreme north of Kittson County the Pellucid Locust is very abundant. The two former species prefer the dry and more sandy soil, the latter the richer and moist land.

The third species, the Pellucid Locust, now injurious in the Red River Valley, is quite different from any of the above three species. Many other locusts occur in large numbers in the infested region and are frequently mistaken for the migratory species. A close inspection of the illustrations below will show that they are quite different, and need not, with a little attention, be mistaken for any of the migratory species.

The common native Two-striped Locust is very numerous throughut the infested region, doing considerable damage.

Remedies.—Besides the usual methods of killing locusts, some of which are very valuable if carried out at the proper time, there is but one other excellent remedy left to prevent further injury: plowing the ground after eggs have been laid. This remedy has been applied two years ago on a large scale in Otter Tail County and has proved a complete success. As the conditions in the newly infested regions are similar, there is no doubt that similar results will be obtained if the same remedy is carried out thoroughly. All the locusts now infesting the invaded counties came from fields that were not plowed. In places where the whole of the cultivated soil was plowed, no locusts could be found. Of course at the time of writing this bulletin the state of affairs is different, as the insects have scattered over a much larger area. But if every farmer will plow all his stubble land either this fall, after the eggs have been laid, or in early spring, no fears of losses by locusts need be entertained. But to make the reader understand the case more clearly, it is necessary to describe in detail how the eggs are laid and what effect plowing will have. I quote from Bulletin 8, published by the Station during July, 1889.

To repeat again: "If we desire to get rid of the migratory species of locusts now infesting several counties of the State, it is absolutely necessary to plow every inch of the cultivated ground throughout the invaded region. Of course prairies are excepted, the soil in them being filled with a dense mass of roots, thus being unsuitable for the purpose of egg-laying. Simply cultivating in spring, as advised by some, is perfectly useless and proved a total failure where tried. Summer fallow invites the locusts to deposit their eggs in soil thus prepared, and all land thus treated must be plowed again, either later in autumn or early in spring."

Natural remedies.—There are at this time many natural agencies in our favor and working for us, and no doubt immense numbers of locusts will be killed by them. Nearly if not quite all the parasites known to infest locusts are found in large numbers throughout the invaded region. In some places the Red Mite was found in immense numbers infesting not alone the bulky Two-striped Locust, but also those migratory species which love drier soil. In some fields in which the locusts had hatched nearly every individual had from five to twenty of these mites fastened to its under wings and the locusts were doomed. Evidently they knew this as well, as they did not move about in such a lively manner, but seemed out of sorts. But these were exceptional cases, as all the adjoining fields of wheat were overrun with healthy specimens—too healthy to suit the farmer. The explanation lies in the fact that the healthy locusts had escaped all danger from the Red Mites by migrating to the land of plenty, the wheat fields. Numerous other parasites occurred almost everywhere, but chief among them was one of the "old-fashioned" Potato Beetles, or Blister Beetles. This insect (*Epicauta pennsylvanica*) was so numerous as to seriously injure the potato crop. And yet, though very injurious to potatoes, this beetle ought to be protected for once, as in its earlier stage it feeds exclusively upon the eggs of the locust. Many predaceous insects are also in full operation to reduce to some slight extent the numbers of the intruders. It was a cruel yet withal a pleasant sight to see the large numbers of Ground-beetles (*Calosoma calidum*) giving battle to the locusts. Even large specimens were attacked, and notwithstanding a most desperate struggle the locust was soon consumed. Another beetle (*Pasimachus* sp.), much more shy in all its actions, being a nocturnal insect, was found in large numbers engaged in devouring the enemy. Even spiders assist in this good work, and a number of the common Wolf Spiders (*Phydippus tripunctatus*) were seen to attack and kill locusts.

Report to his Excellency Governor W. R. Merriam in regard to the Migratory Locusts infesting portions of Minnesota.

On August 14, 1890, a large swarm of locusts or grasshoppers entered the State of Minnesota. They were observed in a number of places, but chiefly at Crookston, Hallock, and other points in the Red River Valley. This swarm came from the northwest and flew in a southeasterly direction. Through the kindness of the Great Northern Railroad I was enabled last summer to make close inquiry in the regions where this swarm had been observed, and I could follow one that had passed Crookston in an easterly direction to Fosston into the White Earth Indian Reservation, where immense numbers of the locusts composing it had perished in the upper Rice Lake. Close inspection also revealed the fact that eggs had been deposited in some places. At the time in which the above investigation was made it was impossible to obtain many specimens of the insects composing this swarm, but the mutilated material obtained indicated, besides the common native species, at least two species of locusts not usually found with us, one of which was the Lesser Migratory Locust (*Melanoplus atlanis* Riley) and the second a locust evidently belonging to a different genus, but not identified at the time.

As our native locusts do not form swarms like the one invading Minnesota on August 14, 1890, it was quite certain that we had to deal with species more formidable and dangerous, and I deemed it my duty to call attention to this invasion, stating that it was in the line of wise legislation to take time by the forelock and provide the necessary means for suppressing another outbreak. This was done in the last Biennial Report of the Agricultural Experiment Station, page 17. For some reason, however, no action was taken.

When a swarm of locusts passes a region the females, heavy with maturing eggs, are very apt to lag behind and drop to the ground whenever the soil is of such a character as to invite them to deposit their eggs. Suitable for such a purpose is all soil that is well drained and which contains very few roots of plants.

Early in June of the present year a number of letters were received from different parts of the State about exceptionally large numbers of locusts. This was to be expected, even without the addition of the migratory species, as the last few seasons had been greatly in favor of all kinds of locusts and other insects that thrive best in dry and hot summers following a mild winter. The first alarm, in the form of articles in some of our daily papers, came from Pelican Rapids, in Otter Tail County. My investigation of this case showed that a small area near that place had been infested, but chiefly by various native species and the Lesser Migratory Locust. Paying proper attention to this local trouble removed cause for alarm.

The attention of your Excellency was next drawn to the more alarming reports coming from the Red River Valley, and you ordered me to proceed at once to the infested region, and for the last forty days I have been engaged in traveling through the different counties invaded and in instructing farmers in the proper means to combat their enemy.

In Minnesota five counties are infested with migratory species of locusts. Three distinct species, besides the native, are now causing well-founded alarm. The Lesser Migratory Locust (*Melanoplus atlanis*, Riley) is the most abundant species. The true Rocky Mountain Locust (*Melanoplus spretus*, Thomas) is also very common, and the Pellucid Locust (*Camnula pellucida*, Scudd.) occurs also in alarming numbers in the more northern part of the invaded region. The Two-striped Locust (*Melanoplus bivittatus*, Scudd.), though a native species, is exceedingly numerous in many places and causes considerable damage.

The Lesser Migratory Locust occurs in very large numbers in parts of the counties of Polk, Marshall, Kittson, Ottertail, and Hubbard, and extends eastward as far as the cities of Duluth and Tower, St. Louis County, and is doubtless found in more isolated swarms in the whole northern part of the State. The Pellucid Locust

occurs only in the lower or moister parts of Kittson County, and is also found in considerable numbers at Pembina, N. Dak.

We have to deal in this instance with three of the worst species of locusts found in the United States. The region invaded is quite well defined, and the insects occur thus far only in certain spots, but of course this state of affairs will be somewhat changed during the month of August. The central parts of Polk, Marshall, and Kittson Counties from south to north are more or less affected; or, in other words, the sandy ridge running from south to north in above counties is invaded by the Lesser and by the Rocky Mountain Locust. Evidently this sandy ridge attracted the females to deposit their eggs, or the eggs laid elsewhere in the black and more moist soil did not hatch. The former theory is very likely the true one, as the instincts of the female prompt her to deposit her eggs wherever there is good drainage, an important factor to the well-being of the eggs of those insects. But not the whole of this more or less sandy region is thus infested, as the locusts occur only in well-defined small areas. A close inspection of several hundreds of fields revealed the undisputable fact that all eggs laid by the invading swarm were laid in stubble fields and in summer fallow. In no case were the locusts found in the prairie or in fields not surrounded by or adjacent to stubble fields. All the dangerous locusts hatched there and thence invaded the neighboring fields of grain. In a large number of cases the young locusts marched in regular order to the fields of barley, wheat, and oats, and swept away every trace of vegetation for several rods, in some cases many acres. As they grew older they scattered around more, and the exceedingly rank growth of the grain shows at the present time but slight damage. In badly infested fields, however, nearly all the foliage has been eaten, and the heads alone remain. Even these are now devoured in many instances, but only in the more sandy regions. There is still considerable danger to the crops in some parts of the infested regions. As the foliage of the various kinds of grain becomes older and riper it becomes also unfit for food, and the locusts will be forced to attack the growing part of the plants, the heads. In some fields this is already the case, and the locusts eat out the growing kernel, or even bite off the whole ear.

Both the Lesser Migratory and the Rocky Mountain Locust infest mainly the more sandy and drier region of the invaded county. The Pellucid Locust seems to prefer entirely different localities, and is at the present time only found in the lower and moister regions, chiefly in the northern part of Kittson County, and in the corresponding parts of North Dakota. There it is quite injurious, and may prove even a greater enemy than either of the other migratory species.

All these locusts, although very numerous in some regions, are as yet not numerous enough to cause very serious loss to the general crop. Many farmers will lose a large part of their crops; some few may lose even everything.

All these species of locusts, being fresh arrivals from the Northwest, are in a remarkably healthy condition, and consequently much more dangerous than if they had been here some time longer. The two species, loving dry and warm soil, show this to a remarkable degree. If stubble fields in which the eggs were laid are investigated at this time it will be found that fully one-half of the locusts are infested with their deadly enemy, the Red Mite, and this in most instances to such a degree that they will be disabled and unable to deposit eggs for another generation. But if we investigate the adjoining fields, with their promising crops of grain, we soon discover a very different state of affairs. Here almost every locust is free from parasites and enjoying life in grasshopper fashion to the fullest extent, and the intruders will be able to deposit immense numbers of eggs. Evidently the locusts infested with parasites take a gloomy view of life, and have lost their usual energy to such an extent as not even to migrate to the adjoining land of plenty. The common Two-striped Locust of the Red River Valley, although quite an injurious insect if numerous, is now badly infested with numerous kinds of parasites and is consequently to be considered as a friend, since the parasites infesting it will next spring take pos-

session of the invading species. All the important species of parasites occur in fairly large numbers throughout the infested region. One species, the common Black Blister-beetle, is at this time so numerous as to seriously damage the potato crop; it is even much more numerous and injurious than the Colorado Potato-beetle.

Considering the locust invasion in all its bearings, the true state of affairs may be summed up in a few sentences. There are not enough locusts to seriously injure the crop of 1891, though some farmers will lose considerable. Many parasites are at hand to assist us in 1892. The great bulk of the invading species are still remarkably healthy, and will lay enough eggs to produce immense swarms in 1892 if not prevented by artificial or natural means. They are still local, and can be exterminated by energetic and prompt means.

Your Excellency, knowing the great danger of another locust trouble, perhaps similar to that experienced from 1872 to 1876, has taken the only possible way to prevent it by instructing the county commissioners of the infested regions to take the proper steps for fighting these insects. Some of the commissioners thus called upon have responded cheerfully and have acted at once, but others do not seem to consider the locusts as dangerous enough to cause serious losses. Such a view is very short-sighted. Even if these injurious insects do not seriously endanger the crop of 1891, they will assuredly do so in 1892 if not stamped out in time. "An ounce of prevention is worth a pound of cure" is an old saying, but a very true one, and ought to be made the leading impulse in our work against these intruders. In Polk County a large number of hopper-dozers have been in operation under the intelligent and energetic leadership of the chairman of the county commissioners, and have done good execution. As all the locusts, or nearly all, were already winged when the machines were put in operation, very little could be done with them during the warmer parts of the day, but late in the evening, during the night, and early in the morning, when the insects are sluggish and crawl up to the highest parts of the plants, immense numbers were killed, and many fields could thus be saved. At the present time the grain is too far advanced to use such machines, except in extreme cases. The only remedy, and the only one that will effectually do the work, is plowing all the fields known to contain the eggs of locusts. If a good crop is secured next month a large portion of the cultivated land will be plowed, thus killing off immense numbers of locusts in 1892. But all the other cultivated land should also be plowed after the eggs have been laid. The locusts have commenced to mate and will soon deposit their eggs, and continue this work until sometime in September. This time of egg-laying depends, of course, upon climatic conditions, and may be greatly shortened or lengthened. At all events, however, no land should be plowed before all the eggs have been deposited. If already plowed, or plowed before the eggs have been laid, a second plowing later in autumn or as early as possible in spring will be absolutely necessary. The locusts prefer ground free from roots and well drained. Such ground we furnish them now by summer fallow and later by early plowing. All fields treated in this manner are very suspicious and ought to be plowed again.

I have recommended that instead of summer fallowing, to plow now only to a depth of 2 inches and later to the usual depth. Concerted action is absolutely necessary, and the ignorant or slovenly farmer should not be permitted to endanger the future crops of his neighbors and perhaps that of a large part of the State. The county commissioners can help greatly in this good work, and should, if necessary, force all farmers to do their duty to themselves and to their fellow-farmers. In this connection permit me again to call your attention to the fact that the State of Minnesota needs some laws to protect the good farmers against injurious insects raised by the poor ones. Locusts ought to be classified with certain contagious diseases, like the smallpox, for instance, and similar laws ought to be framed to suppress these insects as such diseases.

Generally speaking, the climatic conditions prevailing this summer have been

greatly in favor of the farmer and have been and are against such of the migratory species of locusts as love and thrive best in a hot and dry season. This will account for the fact that but few locusts have been seen flying long distances. The great abundance of moisture has made them sluggish and prevented their flight. Long continued moisture is very injurious to insects of that order, and may greatly assist us by diminishing their number, by enfeebling many, and by preventing the depositing of eggs, except in certain regions well drained. But it would be very unwise to trust entirely to such favorable climatic conditions or to any other natural means to help us. We must help ourselves, and only conscientious work will attain that end. If favorable climatic conditions should assist us it will still be necessary to inspect carefully all infested or even all suspected fields, and have them plowed regardless of cost.

As usual in such cases, the railroads in the infested regions have shown their interest in the war against the locusts, and thanks are due to both the Great Northern and Northern Pacific railroads for furnishing free transportation over their lines.

Very respectfully, yours,

OTTO LUGGER.

ST. ANTHONY PARK, MINN., *August 1, 1891.*

THE LOCUST PEST IN IDAHO—SUMMER OF 1891.

Soon after returning to Lincoln, Nebr., from the Washington meeting of the official entomologists of the country, I started for the West to investigate the actual condition of the locust plague in central Idaho. Although the season had advanced beyond the time for the best results to be obtained from such an examination, it was still thought advisable to visit the region known to have been overrun last year. Especially was this thought the proper thing to be done since a number of appeals for aid had been received by the Department from citizens of the infested region. Leaving Lincoln on the morning of the 27th of August, Soda Springs, in the southeastern part of Idaho, was reached early on the morning of the 27th. At this point the first stop was made for the purpose of ascertaining whether or not the locust plague had reached this portion of the State. Two days were spent here, during which time much of the surrounding country was visited. While no locust pest occurred here it was plainly noticeable that *Camnula pellucida* was greatly on the increase since last year's visit. This locust was quite abundant upon the hay fields and along all irrigating ditches. Inquiries among the various ranches from some of the surrounding valleys indicated about the same condition of affairs at all points. On the 29th I went on as far as McCammon, on the Port Neuff River. Here *pellucida* was also rather commoner than usual, while *Melanoplus atlanis* and *M. femur-rubrum* were too plentiful to inspire one with thoughts of peace from the standpoint of locust ravages in the near future. Next day a stop was made at Pocatello and another at Shoshone. At this latter place it was learned that the locusts had been exceedingly numerous about four to six weeks previously, having come down Wood River from Camas Prairie, doing much damage as they went. A few eggs were also reported to have been deposited in several localities below

Shoshone; but how extensive these egg deposits were could not be definitely ascertained at the time. If the main body of the locusts had moved on down the river as reported there were still plenty of them left behind to mark the line of march, although this could easily have been detected without the presence of these stragglers. The bared fields and cropped grasses on the range alone were sufficient to mark the line of march of the ravaging army.

At first the locusts that were seen from the train at stations along the line of the railroad were mostly *pellucida;* but, as the mountains were approached, several species of *Melanoplus* were also noticed in considerable numbers. In the vicinity of Hailey the pest was quite apparent in the damaged condition of the grasses on the range, as well as in the appearance of the vegetation upon cultivated grounds. The scourge had passed through here before going down the river towards Shoshone; and, as appearances would indicate, this swarm divided at Spring Creek, a part of it going to the eastward towards the Lost Rivers and Birch Creek, all three of which streams with their valleys were reached by the moving hordes of hungry insects, the other portion, as already indicated, going down Wood River past Shoshone.

A stage ride of 31 miles across the mountain and valley brings one to the town of Soldier in the center of the rich Camas Prairie country—a valley of considerable extent and wonderful fertility. This valley has been the cradle for the present locust plague which is now spreading over the surrounding portions of the State. Five years have elapsed since the insect was first observed on the prairie in destructive numbers, but with each successive year the plague has greatly increased and spread over more territory. At first the pest covered but a few square miles of country and did but little damage; the next year it became noticeably more numerous and began moving outwards in various directions from the center of its hatching place, and much more damage was done both to grasses and to grain and other cultivated crops then growing upon the fields of the few settlers who had located and started homes for themselves in the valley. Even at this time it would have been possible to have exterminated the pest in the valley had only a few determined persons attempted to do so. By the time the third summer had come and gone, along with its increase in the numbers of locusts present and the amount of damage wrought, the settlers began to become discouraged. Still no efforts whatever were made towards mitigating the evil. This third year of the pest was a notable one, since just before egg-laying time arrived every single hopper was reported to have left the low lands in the valley for the foothills adjoining, where they laid their eggs. As most of the insects moved in a northeasterly direction when leaving the valley, this movement gave some new hopes to the, by this time, nearly discouraged settlers, for it was hoped that instead of reëntering the valley the young, upon hatching the following spring, would pass on to the northeastward. The ensuing

winter was one of uncommon severity even for this region, with very deep snow, which, upon melting the following spring, flooded the low lands for a long time. The great amount of water throughout the region caused rank growths of vegetation everywhere. Soon after the hillsides began to be denuded of their mantles of snow and vegetation started, the young locusts began hatching and feeding. Contrary to the expectations of many of the inhabitants of the prairie, the feeding and growing hoppers showed little disposition to move away from the locality. Once, it is stated by several persons who had taken the trouble to watch their movements, these little locusts did start off towards the summits of the mountain chain lying to the north. This was just before they developed their wings and while in the pupal stage. But just as soon as they had wings, and these latter had become sufficiently hardened for use, the entire swarm turned about and dropped upon the valley, massing upon the fields of grain and gardens, which they stripped in a remarkably short time. When all cultivated vegetation had disappeared the native grasses were attacked and devoured. So numerous and voracious were the locusts that, notwithstanding the rank growths caused by the abundance of water during most of the spring and summer, when I visited the region in August the country was pretty well divested of its covering of vegetation. Instead of leaving the valley for the hills as their immediate ancestors of the previous year had done, these locusts of 1890 remained and laid their eggs in the valley, choosing gravelly or somewhat sandy places for the purpose. At the time of my visit most of the eggs had already been laid, and hence it was rather a difficult problem to ascertain the exact extent of these depositions, since but few people in the region had paid the slightest attention to the matter, even after a fourth year of suffering had been passed through. It appears, however, from the number of young locusts that were hatched the past spring that a great portion of the valley was thus occupied.

My examinations of the locusts that remained in the valley at the time of my first visit led me to believe that the plague was about at its height, and I so reported at the time. Whether to have done so was the wisest plan or not I can not say, for on the strength of that report most of the inhabitants of the valley decided that there was no further necessity for fighting the plague—a thing that they had not done in the past nor probably had any idea of trying in the future. There certainly were a number of diseased and parasitized hoppers in the country, besides the entire region was overrun by young toads that promised to be of value the following spring in devouring the young locusts when they hatched. It will be seen by the following account of the locusts in that region during the past spring and summer that my conjectures were probably correct. Although apparently on the decline in Idaho, this particular species of locust covers a much more extended area of country than it has for a number of years.

The winter of 1890–'91 was milder than that of a year before, and less snow fell in the valleys and on the prairie, while just as much or probably more fell in the mountains. Spring was slow in coming, and when it came heavy rains set in with the result of flooding much of the prairie. These rains continued through May, June, and pretty well into July. The eggs left by the locusts the previous year began hatching in due time, and of course the little hoppers to feed. Simultaneously with their hatching and eating they began moving slowly toward the lower end of the valley. Whether all of these were inspired alike with the desire to forsake the region of their début into the world I do not know, but, judging from what little information on this point that I was able to obtain, this desire seemed to be almost unanimous. Be this as it may, perhaps a description of the general lay of the country will better explain what followed later in the season.

Camas Prairie is composed of the valleys of the Malade River and its tributaries, which form a basin-like region lying back of the great Snake River Plain and separated from it by a low range of volcanic mountains. This basin averages about 10 to 12 miles in width and is perhaps between 50 and 60 miles in length. The trend of the valley is from west to east, and its lower end is about 1,200 feet lower than the head. At Soldier, which is near the middle, the elevation above sea level is about 5,300 feet. The Malade River, which is the main stream of the prairie, runs along quite near its southern border, and most of its tributaries enter from the north, where they have their sources among the high mountains. Most of these streams flow in a southeasterly direction across the prairie after leaving the mountains and before entering the Malade.

As before stated, the young locusts, just as soon as they hatched, began moving down the valley. Coming to these different side streams they were unable to cross and hence were obliged to stop. Soon their increasing numbers from daily reënforcements devoured what vegetation there was at hand and they perished from starvation. So say some of those with whom I talked about this feature of the subject under treatment. Others claimed that the little 'hoppers were smitten by disease and perished by the millions from that cause; but, whether from starvation or on account of disease, myriads of them died and were washed away by the waters of the swollen streams and piled upon the banks in great heaps from which, as the heat of summer increased, a stench arose that was very disagreeable to say the least, if not actually dangerous to the health of the inhabitants. Even as late as the 10th of September remnants of these heaps of dead locusts were visible along the banks of Soldier Creek and the Malade River. Notwithstanding the great numbers of these insects that perished during the early part of the season when the country was flooded with water, there were still enough of them left to do more injury to the grain and grasses than was done in the valley the year before. Some

of the ranchers lost all of their grain, while others threshed barely as many bushels as they planted, and none harvested a full crop.

Just as soon as those insects which succeeded in pulling through the wet spring obtained their wings they left for the hills—and there was a host of them that did pull through—most of these passed off to the eastward; but others crossed the low range to the southward and southwest, while a few lingered in the hills and mountains to the north of the prairie. It was lucky, too, for many of the settlers, for the grasses were thus allowed to grow somewhat afterwards for hay. Otherwise it would have been impossible to obtain feed for their stock during the coming winter.

It is hoped by the settlers of Camas Prairie that the greatest danger from this pest has passed, and if the reports in reference to egg-laying for the past summer can be depended upon, I am of the same opinion. It is claimed that but few eggs were laid on the prairie proper, and not many more amongst the surrounding hills and mountains. I must confess that my search for the eggs of this insect while in the region was not very successful; still, there might have been quantities of them in districts not visited or examined. No one can more earnestly desire to see this region free from the pest than I do, for my two visits to the region have brought about a liking for the country, and I have also made many friends among the inhabitants whom I wish to see prosper. Aside from these personal feelings a desire for general welfare prompts me to hope for a speedy relief from the plague. Eggs are known to have been laid at three or four places upon the lower mountains to the north of the prairie, and others in the hills south of the Malade. None of these egg areas, so it is claimed, comprise more than a few acres each.

As would naturally be supposed, the presence of the pest in the same region for a succession of four or five years has resulted in the production of several of its natural enemies in rather abnormal numbers. These, of course, are doing much towards mitigating the evil, but as yet they do not appear to have made much of an impression upon the vast throng comprising this plague. Several natural enemies of this locust were observed, such as the Locust Egg-mite (supposed to be the same species that worked on the eggs of the Rocky Mountain Locust in Minnesota and other sections of the temporary region), several of the *Tachinidæ* or Flesh Flies, three or four kinds of Robber Flies (*Asilidæ*), some of the Ground-beetles (*Cicindelidæ* and *Carabidæ*), a couple of species of Blister-beetles (*Meloidæ*), and one or more of the Wasps (*Crabronidæ*). Besides these, during late summer and early fall, the streams of the region were full of one or more species of hair worms (*Gordius*), which most likely had been parasitic within the bodies of this and various other locusts. If everything would continue thus favorable for the increase of these natural enemies of the locust, they themselves would eventually control it; but as their existence is also to a great degree dependent upon certain climatic conditions, it is not a safe plan

to trust too implicitly in them. The settlers must themselves take a hand in the fight if they would be sure of victory. As shrewd as are most of the living things about us, man is shrewder still. Hence, if he undertakes in earnest the task of outwitting any of these lower forms of life, he is bound to succeed. True, there are often many difficulties, apparent or real, to be overcome, but a little judicious planning in the end brings success.

The habits, life-history, and haunts of the Pellucid-winged Locust differ materially from those of the Rocky Mountain or True Migratory one which has received so much of our attention during the past twenty years, and which has finally been obliged to yield the ground to us on account of the mode of warfare adopted. Still, the characteristics of *Camnula pellucida* are essentially similar, and slight modifications in the mode of warfare as used against the former insect will be successful with the latter. The use of the "kerosene pans" or hopper-dozers is quite practicable in most cases against the pest upon the valleys, while plowing for the destruction of the eggs before hatching can be resorted to in a number of instances, both upon rolling and level ground. All this requires work. So does the destruction and keeping down of noxious weeds.

While matters begin to look more hopeful with reference to the Pellucid Locust, upon Camas Prairie at least, I am sorry to be obliged to report that there seems to be a decided increase among several other species of these insects now in the region. Of these latter there are the Lesser Migratory Locust (*Melanoplus atlanis*), the Detestable Locust (*M. fœdus*), the Two-striped Locust (*M. bivittatus*), and *Pezotettix enigma*, for which there is no common name. All four of these locusts were quite plentiful at various points upon the prairie, and especially so in the vicinity of the foot-hills on the north side. In certain localities they were sufficiently numerous to materially injure the grasses and other natural vegetation, and at a few points even did noticeable injury to cultivated crops that had escaped the ravages of *Camnula pellucida* earlier in the season. Of course the undue multiplication of these various other locusts is caused by the same favoring conditions which allowed the *pellucida* to develop in such overwhelming numbers. Whether or not, since most of the swarm of that one has left the valley, these latter will be attacked by the great numbers of enemies which its presence permitted to develop and which it left behind, remains to be seen.

THE DESTRUCTIVE WESTERN CRICKETS.

While not exactly locusts, these large wingless insects which are usually known by the name of Western Crickets need mention in this connection. A number of years ago, during the days of geological survey expeditions, and when the first fieldwork of the United States Entomological Commission was being done, these insects were frequently seen in immense droves moving over the country like so many sheep.

During more recent years, however, they have been less numerous, and hence but little has been heard of them. The true home of one of these insects is the great plains of the Snake River, where sage brush reigns supreme as the vegetable product of the country. Beyond this limited region the insect is only occasionally met with in droves. Its distribution reaches over the Great Salt Lake Basin into northern Oregon, on the Spokane Plateau of eastern Washington, into a few of the valleys of western Montana, and at long intervals it is even met with in western Wyoming. In addition to this species, which has been called *Anabrus simplex*, there are quite a number of allied species, to be met with in the same region as well as elsewhere. The most of them are, however, denizens of the arid and semi-arid regions of the West and Southwest, where they either wander about singly or in pairs, feeding upon the scant vegetation. As a rule each species is confined to a rather limited area, and prefers some special plant as its leading diet. As with all other rules, there are exceptions to this one also. A few species of these crickets have a very wide distribution and enjoy a greatly varied diet. Some species are inhabitants of elevated mountain slopes and valleys, while others occur far out on the grassy plains of Nebraska and Kansas.

As a group this subfamily *Decticidinæ*, among the other Orthoptera, has been greatly neglected in our country. But few of the forms have thus far even been honored with a scientific name, to say nothing of their life-histories, habits, enemies, etc., which are still to be learned. Truly, they have thus far been a neglected lot!

The reason for my speaking of these crickets now is the reappearance of two species of them during the past season in great numbers over a considerable territory. Early in July it was known that a swarm of *Anabrus simplex* was forming somewhere in the region between Mountain Home and the Camas Prairie country, where they had hatched earlier in the season from eggs laid last fall. After forming, this main swarm of the insect started in a northeasterly direction, crossing the divide and entering the prairie nearly south of the town of Soldier. After entering the valley most of the insects kept right on their course which they had apparently chosen, but many of them left the main body and scattered over the whole region drained by the Malade. Judging from the information obtainable, this must have been a very large swarm indeed, for it was claimed that the insects covered a tract nearly or quite 3 miles wide by 9 miles long. I first met the insect in considerable numbers a couple of miles out from Hailey, and found them more or less plentiful at various points along the road for 20 miles. They were seen again a couple of days later in the foothills north and west of Soldier, where a few of them were still apparently depositing eggs. While engaged in this act the female becomes so intent upon her work that she can be approached and watched without being at all disturbed. The long strong ovipositor is gradually worked into the hard earth by a series of backward and

forward sliding thrusts, with an occasional side movement. In this manner the hole thus formed becomes a little elongate in form and somewhat larger at the lower end than above, making an enlarged cavity for the reception of the eggs, which are irregularly arranged. These eggs are somewhat curved, of dark brown color, of an average size for the insect which lays them, being nearly one-third of an inch in length and are somewhat flattened, but otherwise do not differ much in form from those of an ordinary grasshopper, or locust as they should be properly called. They are not all laid at one time, but, judging from dissections made of the female, 15 to 18 are laid in one cluster, other deposits following at intervals of several days during the fall. Last summer they began laying about the middle of July and continued during the first week in September. It was not definitely settled as to the arrangement and number of eggs laid in a single cavity, but the figures given above can be taken as approximately correct.

A second, but much smaller, species of these crickets also occurred in numbers near and among the foothills of the mountains adjoining the prairie. This latter species is evidently the one described by Prof. Cyrus Thomas as *Decticus trilineatus*, though from its great variability in coloration and markings it is quite difficult to decide this for a certainty without careful comparisons of a number of specimens with the description. Contrary to the clumsy movements of the large *Anabrus simplex*, this smaller cricket is one of the most active insects in the region, and to capture a specimen of it during the warmer part of the day requires considerable dexterity on the part of the would-be captor. Its egg-laying habits were not ascertained since it apparently had not yet begun operations in this direction.

Some apprehension is felt by many of the inhabitants that this latter insect will also become injurious, since it was noticed for the first time the present year in such numbers as to cause alarm. I do not think that such is liable to be the case, since it appears to be partial to damp places covered with rank vegetation rather than to the more dry open country. It occurred in the mountains at an altitude of 9,000 feet above sea level or near timber line, as well as down in the valley below the 5,000 feet point.

The migratory habit in *Anabrus simplex* and several others of these large, wingless, cricket-like insects is very marked at times; but much more so when they are present in large numbers. As with many other insects when they develop in excessive numbers, the desire to move in great crowds seems to take hold of these crickets. At such times they move towards central points and congregate into companies, after which they strike out in a body in some particular direction. When moving they are said to turn neither to the right nor to the left, but to keep on in a direct line, climbing over obstacles rather than going around, and even plunging into streams which happen to run across their course of travel. When these streams are encountered, if not too

large, they are soon filled to such an extent that the oncoming hordes soon are enabled to cross over on the bodies of the unfortunate leaders that reached the stream first. It has never been my fortune to see a swarm of these insects crossing anything larger than a small irrigating ditch, hence it is a difficult matter for me to accurately describe one of these crossings. They are also said to be capable of being driven "just like a drove of sheep" when they have stopped to feed; and at such times are often "herded" off gardens and fields of grain.

LOCUST INJURIES IN OTHER REGIONS DURING THE SUMMER OF 1891.

Before closing this report it might be well to refer to such other locust depredations occurring during the summer as have directly or indirectly come to my notice. Of course, these were most of them quite local and limited in their extent, and were occasioned by local non-migratory species. Taking them at random rather than in accordance with their magnitude or importance they can be briefly stated as follows:

A region of considerable extent in southwestern Kansas was overrun to some extent by the large yellow locust known as *Melanoplus differentialis* and several other species in fewer numbers. These mostly damaged the alfalfa and materially lessened the hay crop of that region. Professor Osborn, of the Iowa Agricultural College, who visited the region by your request, has already given a full account of this outbreak in a paper read before the meeting of official Economic Entomologists, held in Washington during the month of August. Hence, I will merely refer to it here.

Farther south and west, in New Mexico and Arizona, locusts were reported as being very numerous and moving eastward. It was claimed in the reports that the damage being done here was chiefly to the grasses on the range. Just what species of 'hoppers were engaged in these injuries, and how extensive they were, could not be learned at the time. Possibly it may have been the Long-winged Locust which also occurred in Colorado and did like injury there. At any rate the mention of their "moving in droves while yet unfledged" would be quite characteristic of the *Dissosteira longipennis*. Letters received from Professor Townsend, of the New Mexico Agricultural College, quite recently, throw a little light upon some of the locust injuries wrought in that particular region during the year. He states that the *Acridium shoshone* and a species of *Melanoplus* have been numerous during the past summer and were the cause of some slight injury to certain crops and wild plants. The *Acridium shoshone* worked on the Mesquite and other shurbs and trees, while the *Melanoplus*, which was probably the *differentialis*, attacked and slightly injured the vine.

Reports also reached us here in Nebraska that there were locust depredations being committed in portions of Texas. These reports were found in the columns of the daily newspapers. Just how extensive and at what particular point these injuries occurred in that State I

have been unable to determine. A Government agent was sent out to investigate this particular region, but, I believe, was unable to locate it. It is quite possible that it was some very local injury caused by the *Melanoplus robustus*, *Dendrotettix longipennis*, or *Schistocerca americana* that gave a foundation upon which to build these reports, which afterwards grew as they traveled. Or, it may be that this and other reports of the presence of grasshoppers in destructive numbers which agents afterwards failed to substantiate originated with newspaper correspondents who did not wish to be outdone by co-workers in other sections of the country who had reported bona fide swarms of these insects.

Here in Nebraska there has been more or less injury from *Melanoplus differentialis*, *M. bivittatus*, and *M. femur-rubrum* during the summer; but nothing serious has occurred, nor is there any indication of special injury for next year. This injury during the present year has been confined principally to cities and towns where poultry and wild birds do not have access to old weedy gardens and vacant lots where the 'hoppers are allowed to deposit their eggs and hatch from year to year. Hence the increase and subsequent injury.

While in attendance at the Washington meeting of the Association of Economic Entomologists last August considerable interest was manifested by those present in the locust question for the country at large during the present season. In the discussion that followed the presentation of several papers bearing upon the subject, different entomologists reported the presence of larger numbers of these insects than usual in Alabama, Mississippi, Michigan, New York, Ohio, Indiana, and Iowa. Of course different species of these insects were the guilty ones in different regions; but for the most part *differentialis*, *bivittatus*, and *femur-rubrum* were responsible for such injuries in these States, from which we have no special reports.

These reports of locust injury, coming as they do from almost every section of the country, tend to show that the insects of this group are greatly on the increase, and that unless checked by natural causes, or unless early efforts are made by the people interested to check them, much greater injury must be expected in the near future. True, this excessive increase in so many species and over so wide a scope of country is due to some special cause or combination of such causes, which may seldom or never occur again. Still there is no telling what the future may hold in store. So the wisest plan, by far, as already intimated, is to help ourselves wherever we can. In the present case in particular it should be our aim to do this, since it has been demonstrated time and again that these locusts can very readily be kept in check by ordinary means.

REPORT ON THE LOCUST INVASION OF CALIFORNIA IN 1891.

By D. W. Coquillett, *Special Agent.*

LETTER OF SUBMITTAL.

Los Angeles, Cal., *October 15, 1891.*

I submit herewith a report of my investigations of the locust invasions of California during the past season. These investigations were made principally during the month of August, and conducted in accordance with your instructions of July 27, 1891.

Respectfully yours,

D. W. Coquillett.

Prof. C. V. Riley,
U. S. Entomologist.

According to directions I proceeded, on July 30, to that portion of the State invaded by the locusts, or grasshoppers, stated in the telegram to extend from Merced on the south to Redding on the north. South of Merced County I did not learn that any great amount of damage had been done by the locusts the present season. In portions of Kern County I was informed that the locusts had attacked Apple and other kinds of deciduous fruit trees, but a timely use of the bran and arsenic mixture described in my report to you for the year 1885 (Report U. S. Department of Agriculture, 1885, p. 300) effectually destroyed them.

Arriving at Merced I interviewed Mr. J. A. Norvell, the editor of the *Merced Express*, and learned from him that but little damage had been done in that locality by locusts the present season. He informed me of a new colony that had been recently started near the foothills, where it was reported the locusts had done considerable damage to the young fruit trees. Accordingly I paid a visit to this colony, and found that about 100 acres of deciduous fruit trees had been either partially or completely defoliated by the locusts; all of these trees had been set out less than a year ago. The land on which these trees were growing had been previously sown to wheat, and wheat fields were on every side. Prune and pear trees had suffered the most from the ravages of the locusts; peach and fig trees were but little injured, while Eucalyptus

trees were untouched. It was reported to me that the locusts had also injured cabbages, tomatoes, and alfalfa. I noticed that the rank grass growing in wet places adjacent to the defoliated trees gave no evidence of having been attacked by the locusts, nor did I see any of them upon it. In the trees I found a few specimens of adults of the Devastating Locust (*Melanoplus devastator* Scudd.), but did not find any of their larvæ or pupæ. I was informed that nothing had been done to destroy the locusts or to protect the trees and plants from their ravages, except by the use of barnyard fowls, or by occasionally driving the locusts out of the trees and killing them with shovels or other instruments.

I also visited the Buhach plantation, where the locusts were so abundant in the year 1885, but learned from the foreman, Mr. Davis, that they had not appeared in large numbers the present season, and what few had appeared were destroyed by the use of the bran and arsenic mixture above referred to. A drive over this and neighboring ranches failed to disclose any injury to trees or plants that had been occasioned by locusts the present season.

From Merced I proceeded to Sacramento, and on the way, after crossing the Merced River near Livingston, we encountered quite large flocks of the Yellow Locust (*Trimerotropis pseudofasciata* Scudd.); and this continued, but in smaller numbers, until we reached the Tuolumne River near Modesto. Next to the Devastating Locust, this species was the most abundant in Merced County in the summer of 1885, and was especially injurious to the leaves of grapevines and small trees. In the present locality are immense grain-fields stretching away as far as the eye can reach, dotted here and there with a farm house surrounded by a few trees and grapevines; still I could not discover that any of these trees or vines had been injured by the locusts.

Arriving at Sacramento, I interviewed Mr. McClatchie, one of the editors of the *Sacramento Bee*, and learned from him that the locusts were very numerous in the eastern portion of Sacramento County. Accordingly I went out to Folsom, where I spent three days investigating this subject. In the town of Folsom very little damage had been done by the locusts the present season; in fact, I saw only one orchard that gave evidence of having been visited by them. To the northeast of Folsom are large vineyards and several orchards of deciduous fruit trees, but none of these gave any evidence of having been attacked to any great extent by locusts the present season, nor could I learn that the locusts had been there in large numbers.

These vineyards and orchards are located in the foothills and are surrounded on every side by trees and small bushes.

I went as far eastward as Shingle Springs, in Eldorado County, but could not learn that the locusts had been very numerous the present season in any portion of this county. West of Folsom are several hundred acres of vineyard and orchards that had been attacked by the locusts the present season, and in one of the vineyards I found the De-

vastating Locusts still present in immense numbers; but very few vines had been completely defoliated by them, and the green grapes were almost untouched, although large patches of the green bark had been gnawed from the vines by the locusts. The foreman of this vineyard informed me that he had not used the bran and arsenic mixture for fear of injuring the sale of the table grapes; but it seems to me that there need be no fear on this account, since the sugar or molasses used in making this mixture causes the arsenic to adhere to the bran, the whole forming a compact mass which is not easily blown about by the wind. I noticed that the oak and pine trees growing in the immediate vicinity of this vineyard had not been attacked to any great extent by the locusts, and in a piece of weeds adjoining this vineyard on the west I found very few adults and no young of the Devasting Locust. The weeds along the sides of the roads in this vineyard had been burned off when the young locusts were first noticed for the purpose of destroying those that had hatched out in such places, but during my visit to the vineyard on the 3d of August I found several young of the Devasting Locust on the grape vines growing next to the roads, indicating that the burning process had not been entirely effectual.

In the more central portion of this vineyard, away from the roads, I did not find any of these young locusts, nor did I find in such places any other kind than the Devastating Locust. I was informed that these locusts came into the vineyard from all directions, while higher up in the air could occasionally be seen swarms of locusts, presumably of this same species, which were going westward.

Among deciduous fruit trees, cherry trees appear to have suffered most from the attacks of the locusts, which had not only completely defoliated them but had also eaten out the dormant buds. Pear trees had also been completely defoliated, while apple, quince, apricot, prune, and plum trees had shared a similar fate, but the green pears, quinces, and prunes escaped uninjured. On the apricot trees large patches of green bark had been gnawed away by the locusts, and the twigs thus girdled nearly always died. Young peach trees had been defoliated by the locusts, but the leaves of the older trees appeared to be distasteful to them, as it was very rare to see a peach tree over 6 feet high that had been completely stripped. On such trees it was no uncommon thing to find that every green peach had been eaten, nothing but the bare pits being left, these sometimes still clinging to the trees, but more often lying upon the ground beneath them. Orange and walnut trees and English Holly were completely defoliated; pine and cypress trees were slightly eaten. I saw several California palms (*Washingtonia filifera*) that had been considerably eaten by the locusts. Egyptian corn growing in the immediate vicinity of trees that had been defoliated by the locusts escaped untouched, and this was also the case with several mulberry trees, although it was reported that the locusts fed upon the fruit of this tree. Fig trees also were but little

attacked by the locusts, although rarely in the case of young trees not only the leaves but also the ends of the green branches were devoured by them. I saw a row of fig trees almost surrounding an orchard of deciduous fruit trees, and while the latter had been nearly defoliated by the locusts the fig trees were almost untouched. It was also reported to me that the locusts would not attack the figs upon the trees.

The above-mentioned orchard and vineyard were nearly surrounded by wheat fields and pastures, while but a few miles east of them and separated by a range of wooded hills is a number of small vineyards and orchards that had not been touched by the locusts. These latter vineyards and orchards were surrounded on all sides by woods. Thus it appeared that orchards and vineyards located in the vicinity of grain fields suffered more from the attack of the Devastating Locusts than did those situated in the woods; and this observation was frequently verified during the remainder of my investigations into this subject. There appears to be something about a grain field that is very attractive to the locusts while they are on the wing high in the air; it may be the bright glistening of the sun upon the yellow straw that attracts their eyes. At one place in San Joaquin County the road had been covered with straw for a distance of several hundred yards, and in driving over this in the middle of the day I noticed that hundreds of the Devastating Locust were resting upon the straw, but none, or only a very few were to be found upon the bare ground near it. I was informed by several persons who had witnessed the coming of these locusts that the large swarms would always alight in a grain field, and from this point they spread in all directions to the adjacent orchards and vineyards. My own observations confirmed this fact, since in nearly every instance the trees around the edges of an orchard had been injured to a greater extent by the locusts than had those in the more central portion. In several instances I saw small orchards which were located only a few yards from the breeding grounds of the Devastating Locust, but separated from them by trees and small bushes, and yet the trees in such orchards had scarcely been attacked by the locusts, while orchards located 30 miles distant, but surrounded by wheat fields, had been almost completely defoliated by locusts which had evidently hatched out in the breeding grounds referred to.

From Folsom I returned to Sacramento and interviewed Hon. Edwin F. Smith, the Secretary of the California State Agricultural Society, and from him I learned that the locusts were very numerous in certain portions of San Joaquin County. I therefore proceeded at once to Lodi, where I met Dr. E. Armstrong, a prominent orchardist of that region, who gave me a great deal of information upon this subject, and also showed me over that portion of San Joaquin County that had suffered most from the attacks of the locusts. Here the conditions were practically the same as I had found them existing in Sacramento County. The orchards which had suffered most were surrounded by

wheat fields; the locusts were reported to have come into them from all directions, while others high in air were moving to the westward. Almond trees had been almost completely defoliated; in many instances the outer part of the nuts had been devoured, and more rarely the hard shell of the three-fourths grown nuts had been eaten through and the kernels devoured. A few large peach trees were scattered through the almond orchard, but these had scarcely been attacked by the locusts. Pear trees had been completely, and locust trees nearly, defoliated by them.

I went as far eastward as Valley Springs, in Calaveras County, but did not find any other locality where the locusts had been unusually abundant and destructive the present season.

From Lodi I went to Marysville and interviewed Mr. G. W. Harney, President of the Yuba County Board of Horticulture, and learned from him that the locusts had been quite destructive to some young fruit trees and grapevines in the southern part of that county. Accordingly, in company with Mr. Harney I visited the locality referred to, and found that the trees and vines had been planted out less than a year ago; many of them bore evidence of having been attacked, but only a very few of them had been completely defoliated. Mr. Harney informed me that when the locusts first began to appear in destructive numbers he had several hundred circulars printed, giving directions for making and applying the bran and arsenic mixture above referred to, and these circulars he distributed to nearly all of the fruit growers in the county; as a result, this mixture was largely used in those localities where the locusts made their appearance in destructive numbers, and proved very effectual in destroying them. We visited portions of the county, distant about 15 miles from Marysville, but did not find any other locality that had suffered from locust attacks.

The following day was spent in visiting various portions of Sutter County, in company with Mr. R. C. Kells, the president, and Hon. H. P. Stabler, the Secretary of the Sutter County Board of Horticulture; Mr. Cutts, a prominent business man of Marysville, and owner of a large orchard in Sutter County, also accompanied us. We visited a large portion of the northeastern part of this county, but found only one locality where the locusts had appeared in destructive numbers the present season. This was in an orchard of deciduous fruit trees, several of which bore evidence of having been attacked, although none of the trees had been completely defoliated. The owner informed me that he had made use of the bran and arsenic mixture and this had effectually destroyed the locusts before they had materially injured his trees. The next day, in company with Mr. G. W. Harney, I visited portions of Butte County, in the vicinity of Oroville. I did not see any indication of locust attack in this city, nor could I learn that the locusts had appeared there in destructive numbers the present season. A few miles west of Oroville several small orchards had been

planted out less than a year ago, and a few acres of these trees had been completely defoliated by the locusts. I learned that when the latter appeared upon the trees nothing whatever was done to stop their ravages. They had also appeared in large numbers upon the young trees in the adjoining orchards, but had been destroyed by the bran and arsenic mixture that had been put out when the locusts first made their appearance. We also visited a certain locality about 8 miles south of Oroville, where a large tract of land had recently been set out to fruit trees; here but little damage had been occasioned by locusts.

From Oroville I went by stage to Biggs, in the southwestern part of Butte County; the country passed through was mostly bare pasture lands, where very few locusts of any kind were seen. From Biggs I took the train to Redding, in Shasta County, and interviewed several persons there; from them I learned that locusts had not appeared in large numbers in that locality the present year, nor could I learn that they had been at all numerous in this State north of Redding. I learned, however, that several small orchards in the vicinity of Cottonwood, in the southern part of Shasta County, had suffered from the attacks of locusts. Accordingly I returned to Cottonwood and spent the greater portion of a day in that vicinity, and found that the injury to the orchards occasioned by locusts was slight, there being but few orchards in that locality and these very small ones. This completed my observations in the field, and I returned to Los Angeles by way of San Francisco. At the latter place I visited the Academy of Natural Sciences and obtained the names of the birds and plants referred to in the subsequent pages of this report.

As was the case in the year 1885, the species of locust that had produced the greatest amount of injury the present season is the Devastating or California Locust (*Melanoplus devastator* Scudd.). These always have a small blunt spine in the middle of the breast between the front legs, and the hind or under wings are wholly hyaline or glassy. The colors vary to a considerable degree; in normally marked individuals the ground color is dark gray, and there is a blackish stripe along each side of the thorax, several black spots on the front wings, and a series of black marks on the hind thighs, but in a few individuals the ground color is a very pale yellowish, and the black markings above referred to are very indistinct or are sometimes entirely wanting. These pale individuals belonged to both sexes and are doubtless immature specimens, which later in the season will acquire the normal black markings of the other and more mature form. I submitted specimens of these pale-colored individuals to Professor Riley, who wrote me that they belonged to *Melanoplus devastator*, and he also referred the darkly marked specimens to the same species. Both of these forms have the hind tibiæ, or shins, of a bluish color, but I found associated with them, both in the breeding grounds and also among those that had migrated to the orchards and vineyards, a form which resembled them in colors

and markings, except that the hind tibiæ were of a light reddish color. All the specimens that I captured of this red-legged form are females, and Professor Riley writes me that he is unable without the male to decide to what species they belong. I strongly suspect that they simply constitute a color variety of *Melanoplus devastator*, since such varieties are known to occur among several of the species of this genus found east of the Rocky Mountains. These three forms, which, as above stated, probably belong to one and the same species, were the only spine-breasted locusts with long wings that I met with during my investigations. I also found two or three species of spine-breasted locusts with short wings, belonging to the genus Pezotettix; but these were mostly found in the dry pastures, and only in limited numbers.

Among the spineless-breasted locusts, the species I met with the most often is the Red-winged Locust (*Œdipoda venusta* Stal.); this I found in almost every locality visited, but never in large numbers. The next most abundant species, and one of the largest found in this State, is the *Dissosteira spurcata* of Scudder; this is more local in its distribution than the preceding species, and is usually found in dry pasture lands, sometimes occurring in quite large numbers. The male of this species is much darker colored than the female, and has a curious habit of hovering in the air for several minutes at a distance of 16 or 18 inches above the female.

The Pellucid-winged Locust (*Camnula pellucida* Scudd., of which *Œdipoda atrox* Scudd. is a synonym), which was reported as being very destructive during several successive years in the past in Sierra Valley, lying partly in Sierra and partly in Pimas counties, in the very heart of the Sierra Nevada Mountains, I met with at only one place; this was on an open hillside in Calaveras County, August 8, but they were not at all abundant, and I saw only about two dozen specimens in an hour's search. I dissected several of the females, and the ovaries contained nearly fully formed eggs. Several other species of spineless-breasted locusts were also met with, but these were so few in number that no further mention of them need be made at the present time.

BREEDING GROUNDS OF THE DEVASTATING LOCUST.

Up to the present time but little seems to be known concerning the early stages of the Devastating Locust. I have not been able to find any published notice stating that any observer had seen these locusts paired, or had observed the females laying their eggs, or had found the eggs of this species. During the present investigation I paid especial attention to this part of the subject. Although repeatedly sought for, I never found any of the young of this species in the more central portion of cultivated orchards and vineyards, nor in grain fields that had been plowed and seeded less than a year previously. I also did not find them in thickly wooded land where there was an abundance of small trees and bushes, nor upon the tops or the steep sides of high hills,

nor yet in the low wet grass lands. In the San Joaquin and Sacramento valleys and among the foothills bordering them on the east it was only upon land on which grew a certain kind of weed that I found the young of this locust. I submitted specimens of this weed to Mrs. Dr. Brandegee, the Botanist of the California Academy of Sciences and our best authority upon the plants of central and northern California, and she identified it as the *Hemizonia virgata*, vulgarly known as "tarweed," from the sticky exudations which cover the entire plant. It seldom attains a greater height than 2 feet, the stem is slender, and sometimes bears several small lateral branches, the leaves are small, narrow, and dark green, and the greater portion of the stem is of a whitish, somewhat silvery color. It bears at the tips of its branches yellowish composite flowers, which seldom exceed half an inch in diameter; the leaves on the upper portion do not exceed a quarter of an inch in length. The plant is said by Dr. Asa Gray to be either an annual or a biennial.

In the eastern portion of San Joaquin and Sacramento counties and also in portions of Calaveras and Eldorado counties that I visited, it was rare to find a patch of these weeds in which the young of the Devastating Locust were not present in greater or less numbers; at the same time it was extremely rare to find the young of these locusts in places where none of these weeds grew. I found both these weeds and the young locusts along the sides of the roads, and also upon unplowed land about the orchards and vineyards. They were also sometimes present in fields of volunteer or self-sown grain that had not been plowed for over a year, but were most abundant in the pasture lands among the foothills. Here they usually occurred in the narrow valleys or depressions lying between the hills, sometimes extending some distance up the sides of the hills, but never high up on the sides of very steep hills, nor on the tops of hills, nor yet among the thick underbrush wherever this might occur. Among the foothills of Calaveras County, in the neighborhood of the town of Burson, I found a field of these weeds covering 60 or 80 acres of land, and among the weeds were both adults and young of the Devastating Locust in large numbers. I was informed by a party living in the neighborhood of this field that the young locusts had been extremely abundant there early in the season, and that in the month of May he saw a large swarm of the winged locusts take flight and disappear to the westward; it was reported to me that about this time the locusts were first observed to come into the orchards in certain portions of San Joaquin County, lying in the same direction that the swarm was said to have taken; so it appears quite certain that the large swarms of locusts that swept down upon the above-named county the present season hatched out in this and neighboring fields of tarweeds.

I dissected a large number of the adult females of the Devastating Locust which I found in this field and examined the ovaries, but in none of them did I find any eggs in an advanced stage of development,

nor did I see any of these locusts paired, nor were any engaged in laying their eggs. On the 10th of August, accompanied by Mr. F. V. M. Hudson, of Acampo, and one of his hired men, I spent the greater portion of the day in searching for the eggs of this locust in the above-mentioned and neighboring fields of tarweeds, but did not succeed in obtaining any. This fact, coupled with the further fact that while studying this and other species of locusts in Merced County in the year 1885 I neither saw the Devastating Locusts paired nor did I observe them laying their eggs during all the time that I observed them, extending from the first week in June to the first week in August, and that I did not witness either of these operations during the present investigation which extended over the first three weeks in August, makes it almost certain that this species is single brooded and that the eggs are laid some time during the fall of the year, probably not before the month of October. All the testimony goes to prove that these locusts hatch out very early in the spring. Several intelligent observers informed me that they had seen the young locusts in immense numbers early in April and that these began to acquire wings early in May. The following from the *Folsom Weekly Telegraph* of May 9, 1891, indicates how early in the year these locusts appeared in that locality the present season:

GRASSHOPPERS COMING.

Grasshoppers have appeared in the vicinity of this place. They seemed to come suddenly and from where no one knows. Millions of them are destroying everything they can get hold of, and considerable alarm is felt over their appearance and the result of their visit. They came too late to do any great amount of damage to the hay crop, which is nearly all in. Other things will surely suffer unless they disappear. Those that are here are, from what we can learn, very small, but they are voracious and have done a great deal of damage already. A few years ago they visited the State and caused great damage. There was no way to combat them. We hope the alarming reports regarding them are exaggerated.

The editor of the "Telegraph" informed me that he sent the above as a telegram to the *Sacramento Bee* on the 5th of May, which would put the coming of the locusts at a somewhat earlier date than the one given above.

Hatching out so early in the season and acquiring wings as early as the month of May, it appears somewhat singular that these locusts should not become fully matured and deposit their eggs until nearly six months later in the season. The fact, however, that among the migrating swarms I found very pale-colored specimens that had not yet become sufficiently mature to attain their normal dark coloring as late as the middle of August, indicates that the species is very slow in maturing even after acquiring wings. The destructive Rocky Mountain Locust (*Melanoplus spretus* Uhler), which has as yet never been found in this State, is known to be single brooded in its permanent breeding grounds.

In Los Angeles County, on the 20th of September of the present year, I saw a pair of Devastating Locusts united in coition; this was the only pair I saw in a five-hours' search in a locality where these locusts were quite abundant. I find by reference to my note book that on the 1st of October, 1888, I also saw a pair of locusts belonging to a closely related, but apparently unnamed species united in coition.

On page 21 of INSECT LIFE, Vol. IV, Mr. Lawrence Bruner, one of the agents of this Division, in referring to the Devastating Locust, says: "This species also occurs in two forms, viz, small and large, being the spring and fall broods, as nearly as I have been able to decide from specimens in collections." This supposition, however, is not borne out by the facts, since in the month of August of the present year I collected both large and small specimens of this species in Sacramento County; the smallest specimens measured only 16 millimeters (about three-fifths of an inch) from front of head to tip of abdomen, while the larger specimens, which were captured in the same locality as the smaller ones, measured 25 millimeters (equal to 1 inch) in length. Specimens representing both sizes, as well as others of every intermediate grade, were submitted to Professor Riley, who referred all of them to the above species, so there can be no doubt of ther proper identification.

All the facts therefore seem to indicate that the Devastating Locust is normally single-brooded, and that the eggs are laid in the fall of the year.

Although I saw both the adults and the young of the Devastating Locusts feeding upon the tarweeds in the large field near Burson, referred to above, still they had not completely devoured these weeds, which were still green and growing. Immediately adjoining this field on the west was about half an acre of plants of *Hosackia glabra* that had been completely defoliated, presumably by these locusts; I did not find any young of the Devastating Locust among these defoliated plants. These were the only wild plants I saw that there was reason to believe had been completely defoliated by these locusts.

North of Sacramento I did not again meet with this tarweed; but in Yuba, Butte, and Tehama counties it is replaced by a viscid, glandular plant, which Mrs. Brandegee identified as *Layia glandulosa*. This is a low growing, loosely branched annual, which never exceeds a foot in height; the leaves are narrow, and the composite flowers are white, with a dark yellow center; the entire plant bears numerous short, stiff hairs.

I found this plant growing on the sides of low hills or on the high mesa land, and when found in large numbers it was nearly always accompanied by the young as well as by the adults of the Devastating Locust; and in the above-named region I did not find any of the young of this locust except in places where this weed grew.

One of the most common weeds I met with growing in the dry pasture lands and in the open foothill region in the eastern part of the San

Joaquin and Sacramento Valleys, extending from Tehama County on the north to Merced County on the south, is a low-growing, much-branched, pubescent, whitish plant, which Mrs. Brandegee informs me is *Eremocarpus setigerus*, sometimes known as "turkey-feed," owing to the fact that the turkeys are very fond of it. This plant was present in almost every locality that I visited, but I did not see any of the Devastating Locusts feeding upon it, nor were the young of this locust ever found upon these plants, nor among them except when the latter grew in the vicinity of one or the other of the two plants referred to above. The "turkey-feed" plants evidently had no attraction for these locusts, which appear to prefer plants of a viscid or sticky nature.

Of course it is possible that, in certain localities which I did not visit, the Devastating Locust may breed among other kinds of weeds than the two referred to above, but the fact that I found the young of this locust in almost every patch of these weeds of any considerable size, taken in connection with the other fact that I very seldom found the young locusts except in places where these weeds grew, makes it almost certain that this locust chooses patches of these weeds in which to breed.

CAUSE OF THE LOCUST RAVAGES.

The region of country in this State that suffered most from the ravages of the Devastating Locust the present season is comprised in the three counties of Placer, Sacramento, and San Joaquin. In certain portions of these counties it was reported by several observers that the locusts came from the eastward in large swarms, not all at once, but in two or three separate swarms at intervals of about two weeks apart. From what has already been written it is almost certain that these large swarms hatched out in the open pasture lands among the foothills in the eastern part of Sacramento County, and also in the western portion of Eldorado, Amador, and Calaveras counties, in places overgrown with tarweeds.

The fact that these locusts do not appear in destructive numbers every season has led some persons to believe that these insects—like the misnamed Seventeen-year Locust of the East (*Cicada septendecim* Linn.)—pass several years in the larva state, but of course such is not at all the case; and if the facts were known it would evidently be found that these locusts migrate to the orchards and vineyards every year, but not always in sufficient numbers to attract attention. It appears to be a settled fact, however, that the years in which they have been present in destructive numbers in the region designated above were in seasons when there had been little or no late rains in the spring and when there had been heavy and long continued rains the previous spring. In other words, it appears that there must be a spring of long-continued and late rains, followed by one in which very little rain falls, in order to produce an unusual number of the locusts. These conditions existed in the years 1884 and 1885, and again in 1890 and 1891,

and we find that the locusts were unusually abundant and destructive in the year 1885 and again in 1891.

To give any rational explanation of this phenomenon would require a greater knowledge of the habits and early stages of this insect than we at present possess. It may be conjectured, however, that the long-continued and late rains retard the hatching of the young locusts, and at the same time produce such an abundance of vegetation that the greater number of the locusts would remain upon the breeding grounds the entire season and would deposit their eggs in these grounds late in the fall; thus a much greater number of eggs would be deposited in the breeding grounds than would have been the case had the season been dry and the majority of the locusts migrated from the breeding grounds before their eggs had been deposited. The following season being a dry one there would not be abundance of vegetation, and the eggs in the breeding grounds would naturally hatch out very early in the spring, and the immense numbers of locusts produced would soon reduce the scanty vegetation to such an extent that they would be very anxious to migrate to new fields as soon as they had acquired wings. And this would account for the immense swarms that occasionally appear in this region, and would also account for the fact of their not occurring every season.

While these locusts have been observed to migrate in swarms from their breeding grounds, no person has ever seen them returning to these grounds again, and it seems very probable that they never do so. The eggs of these migrating swarms are doubtless deposited in cultivated lands, and the subsequent plowing and harrowing of these lands evidently destroys the eggs. Thus the species must depend for its continued existence upon the comparatively few individuals that remain upon the breeding grounds throughout the season, or at least until the egg-laying season has passed by.

Several different persons living in the locust-infested district stated to me that the earlier-migrating swarms of Devastating Locusts had deposited their eggs in the cultivated fields and orchards, and that they had seen the young of these locusts in the above-mentioned places. Questioned closely, they all admitted that they had not seen the locusts in the act of depositing their eggs, nor could they refer me to a single person who had seen them thus engaged; but the fact that they had found what they believed were the young of these locusts in the localities mentioned, led them to believe that the earlier broods had deposited their eggs in such situations. I took especial pains to investigate each of these reports, but found that in not a single instance did the young locusts observed belong to the destructive migrating species. In the majority of cases they belong to the young of the spineless-breasted locusts, but in one instance the adults of one of the short-winged locusts, the *Pezotettix enigma* Scudd, were mistaken for the young of the Devastating Locusts; these short-winged locusts have a

spine in the middle of their breast, between the legs composing the front pair, in this respect resembling the young of the Devastating Locust; and although fully developed their wings do not cover the basal half of the hind body or abdomen, thus giving them the false appearance of being young locusts. From the young of the Devastating Locust they can at once be distinguished by never possessing the conspicuous whitish spot found near the base of the wings; and if the wings are more attentively examined it will be found that in the short-winged *Pezotettix* the nerves of the lower half of each wing extend nearly parallel with the lower margin of the wing, whereas in the young of the Devastating Locust the veins run in an oblique direction to the lower edge of the wings. These characters will enable the most casual observer to distinguish the young of the Devastating Locust from any of the short-winged locusts known to me to occur in this State.

NATURAL ENEMIES.

During my visits to those portions of the State that had suffered most from the attacks of the locusts, I was struck with the almost entire absence of insectivorous birds and insects. Of course every collector of insects in this State is aware of the fact that in the month of August insect life is less abundant in the valleys than it is at almost any other season of the year, and this may also account for the scarcity of insectivorous birds in the valleys during this time of year.

Probably the bird that renders the greatest benefit to our horticulturists in the way of destroying locusts is the Arkansas Kingbird (*Tyrannus verticalis* Say), also known as the Arkansas Fly-catcher, and locally as the Bee-bird from its reputed habit of occasionally feeding upon Honey Bees. Near the town of Clements, in San Joaquin County, I saw a pair of these birds perched in a tall cottonwood tree that grew along the edge of the Mokelumne River. This tree stood some distance from the banks of the river proper, and just back of it, and still farther from the river rose a high bluff, the sides of which were almost perpendicular. At certain intervals the Devastating Locusts would rise from the ground along the bank of the river and proceed to fly over these bluffs, but when nearly opposite the tree upon which the Kingbirds were perched, one of these birds would dart forward, seize the locust, and return to the tree again to devour its victim. During the few moments that I watched this pair they captured quite a large number of the locusts, always returning to the same tree to feed upon them. In the American Naturalist for August, 1869, Mr. Robert Ridgway, the well-known ornithologist, makes the statement that a specimen of this Kingbird, which he kept in a cage, devoured 120 locusts in a single day. Were these birds at all numerous, it is evident that they would destroy immense numbers of the locusts in the course of a single season; but, unfortunately, they were only occasionally seen in any of the localities that I visited.

Another bird that also preys upon locusts is the California Shrike (*Lanius ludovicianus gambeli* Ridg.), locally known as Butcher-bird, from its habit of impaling insects, small birds, lizards, etc., on almost any sharp-pointed, thorn-like object within its reach. At several different places I saw one of these birds fly to the ground, seize a locust, and return to its former perch to feed upon its victim; but frequently it would impale the locust upon some sharp-pointed object and leave it there to die. The sharp barbs of a barbed wire fence were frequently used by these birds for impaling the locusts upon, and in driving along one of these fences it was no uncommon sight to see at short intervals one of the locusts thus impaled. Unlike the Arkansas Kingbird, which invariably captures the locusts while upon the wing, this Shrike appears to attack them only upon the ground. Its habit of impaling them upon sharp-pointed objects would allow of its destroying an almost unlimited number of locusts in a day. Unfortunately, this bird is not abundant in any portion of the locust-infested region.

These two were the only birds that I saw capture and feed upon locusts, but Mr. Walter E. Bryant, the Ornithologist of the California Academy of Sciences, to whom I am indebted for the names of these birds, informs me that he has found locusts in the stomachs of the following California birds: Great Horned Owl (*Bubo virginianus* Gmelin); Burrowing Owl (*Spcotyto cunicularia hypogæa* Bonap.); Sparrow Hawk (*Falco sparverius* Linn.); Road-runner (*Geococcyx californianus* Lesson); and Western Lark Finch (*Chondestes grammacus strigatus* Swainson).

While investigating the locust plague in Merced County for the Department in the year 1885, I saw three other birds feeding upon locusts; these were: Bullock's Oriole (*Icterus bullockii* Swainson); California Song-sparrow (*Melospiza fasciata samuelis* Baird), and another undetermined species somewhat larger than the latter, and having a conspicuous patch of red feathers on the crown of the head.

The Burrowing Owl was quite frequently seen, occurring in and about the burrows of the California Ground Squirrel (*Spermophilus grammurus beecheyi* Richardson). These, however, were most abundant in the dry, level plains, where but few locusts occurred. The other birds mentioned above were occasionally met with, but were not at all numerous in the locust-infested regions.

Of the smaller animals, I have seen the Western Fence-lizard (*Sceloporus occidentalis* Baird–Girard) catch and devour locusts. This lizard is commonly known by the name of Swift. This and allied species are quite commonly found all over the locust-infested regions and doubtless destroy a large number of the locusts.

Among predaceous insects, the species which probably destroys the greater number of locusts, and the one most frequently met with, is a medium-sized, wholly black wasp known as *Priononyx atrata* St. Farg. This wasp digs its burrow in the earth, usually in loose sandy soil, and

provisions it with locusts which she catches while on the wing and stupefies them by repeatedly thrusting her sting into their bodies, the point selected for thus stinging them being in nearly every instance the underside of the thorax between the first two pairs of legs. After being stung a few times the locust becomes motionless, and the wasp gets astride of her victim, seizes it by the antennæ, and drags it to her burrow, occasionally leaving it and going off in search of her burrow; after finding it she again returns to the locust and drags it along by the antennæ as before. After it is safely landed in the bottom of the burrow, the wasp deposits one or more eggs upon it, then comes to the mouth of the burrow and with her fore feet scratches the burrow full of earth, somewhat as a dog would do. All of her movements are very rapid, and it is very rare to find her idle, being almost the whole time, at least during the warmer portion of the day, engaged in searching for or dragging along and burying the locusts. I frequently saw one of these wasps thus dragging along a locust, and although other species of locusts were present she always selected a Devastating Locust for her victim.

I also saw another kind of wasp, known as *Polistes variatus* Cresson, feeding upon a recently killed Devastating Locust, while several other specimens of the same kind of wasp were busily looking among the weeds, as if in search of locusts. This wasp is of about the same size as the Priononyx, referred to above, but is of a light-brown color, variously marked with pale yellow. I have occasionally found the nest of this wasp beneath pieces of wood lying upon the ground. The nest is constructed of a bluish gray, papery substance, is of a circular form, and measures about 2 inches in diameter. It is suspended by a rather slender pedicel of the same papery substance, and the cells are on the underside and open downwards; they are filled with a yellowish mass, which probably consists of the masticated bodies of the locusts.

Besides these two species, I have seen a third kind of wasp, the *Tachytes rufofasciata* Cr., dragging along an apparently lifeless locust, which she evidently intended to bury, to serve as food for her young, just as the Priononyx described above was observed to do. This wasp is considerably smaller than the Priononyx, and has the abdomen and a large portion of the legs pale brown.

Besides these wasps, the only other kind of predaceous insect that I saw feeding upon locusts is a large slender-bodied, two-winged fly, known as *Proctacanthus milbertii* Macq. This fly is of a brownish gray or drab color, and the largest specimens measure nearly 1½ inches in length; the legs are stout and covered with spines; the stout, black proboscis projects forward from the lower portion of the head, and the latter on the sides and lower part in front is thickly clothed with rather long whitish hairs. Riding along by the side of a barbed-wire fence in Tehama County, on the 15th of August, I saw a great many of these flies resting upon the upper side of the top wire, while an occasional

one was seen hanging from the under side of the wire, to which it was clinging by the aid of its strong claws, while between its body and the wire, and firmly held in its embrace, was an adult locust, into whose body the proboscis of the fly was inserted. The fly was not particular as to the kind of locust it captured, sometimes catching and feeding upon the Devastating Locust, at other times attacking an undetermined species of spineless-breasted locust. When not feeding, these flies were very shy, taking wing whenever approached at all closely, but when engaged in feeding I had no difficulty in capturing them in my hand. On the same day above mentioned I saw several of these flies paired, but I know nothing in regard to their early stages. Professor Riley has recorded the fact that the larvæ of an allied species, the *Erax bastardi* Macq., feed upon the eggs of locusts, and it is very probable that the larvæ of the present species has the same commendable habit.

Of internal parasites I know of only one species that attacks locusts; this is a grayish black, two-winged fly which closely resembles the common House Fly but belongs to a different family, the Sarcophagidæ, and to the typical genus Sarcophaga; the thorax is marked with three blackish, longitudinal lines, and the abdomen is marmorate with darker spots which are changeable in different lights. I first met with specimens of this fly on the 15th of August in Tehama County; the locality was a small tract of land covered with low-growing weeds, among which were quite a large number of locusts of different kinds. The flies were resting upon dead weeds, stones, etc., and whenever a locust of any kind took to its wings one of these flies would dart after, and appear to strike it, but this was evidently the method in which the fly attaches her eggs to the bodies of the locusts. When thus struck by one of the flies the locust in nearly every instance would at once close up its wings and fall to the ground, as if aware of danger. I did not succeed in breeding the perfect flies from these locusts, but among a large number of insects sent me for names by Mr. E. M. Ehrhorn, of Mountain View, was a single specimen of the same kind of fly which he informed me was received with several others from a Placer County correspondent; the locust which he pointed out to me as being the one from which this fly was bred belongs to the destructive California species, *Melanoplus devastator* Scudd. While at Marysville, Mr. G. W. Harney, the President of the Yuba County Board of Horticulture, showed me a Dipterous pupa which he had bred from one of our largest spineless-breasted locusts, *Dissosteira spurcata* Stal.; but as the fly never issued from this pupa the species to which the latter belongs can not be ascertained, although it is very probable that it belongs to the same species referred to above.

In Merced County, in the summer of 1885, I collected quite a large number of specimens of this same kind of locust, inclosing them in a bottle containing potassium cyanide, and from one of these issued a Dipterous larva, which, however, was not observed until it had been killed by the fumes of the cyanide, so that the species to which it belonged could not be ascertained.

These Dipterous parasites appear to be extremely rare. In every locality visited I dissected large numbers of locusts belonging to various species, but did not find any of them to contain a trace of these parasites. I also brought a large number of the locusts home with me, but up to the present date no parasites have issued from them.

Quite a large number of locusts were infested with small red mites, presumably *Trombidium locustarum* Riley, but these did not occur in numbers sufficient to prove fatal to the locusts they infested.

On page 263 of the Second Report of the United States Entomological Commission, Professor Riley records having bred two different kinds of Bee-flies from larvæ found feeding upon the eggs of locusts in Sierra Valley, California, the two species being *Aphœbantus mus* O. S. (of which *Triodites mus* is a synonym) and *Systœchus oreus* O. S.; but, although I was especially on the lookout for specimens of these two species, I saw only a single specimen of the Aphœbantus. This was in Tehama County, and the specimen was resting upon the doorstep of a dwelling house. During the entire three weeks that I spent in investigating the locusts, the greater part of this time having been spent in the fields, I did not see another specimen of this species, nor of any other species belonging to this or to closely related genera. The Bee-flies that I saw belong to the genera Toxophora, Geron, Anthrax, Argyramœba, and Exoprosopa, none of which in the larva state are known to feed upon the eggs of locusts nor to attack the locusts themselves. Here in southern California I have collected specimens belonging to twenty-two different species of Aphœbantus, several of which occur in quite large numbers; and it is evidently largely due to the presence of these insects that the locusts so seldom occur in destructive numbers in this part of the State.

In the first report of the United States Entomological Commission, pages 297 to 301, Professor Riley gives an extended account of the early stages of three different species of Blister-beetles, the larvæ of which he found feeding upon the eggs of various kinds of locusts in the region of country lying east of the Rocky Mountains. These beetles belong to two genera, Macrobasis and Epicauta, but neither of the three species referred to are found in California. So far as I am aware the genus Macrobasis is not represented in this State, but of Epicauta and related genera my collection contains representatives of nearly two dozen species found in this State, but principally in the southern portion of it. During my recent investigating trip I met with only one kind of Blister-beetle, the *Epicauta puncticollis* Mann., a slender, wholly black species, which, however, was not abundant in any of the localities visited. They were most abundant in the neighborhood of Oroville, in Butte County, where I found them feeding upon a low-growing weed, *Layia glandulosa*, already referred to in the chapter treating upon the breeding grounds of the locusts. Since the Devastating Locusts had bred in the same locality, as was evidenced by my finding the young of

these locusts among the weeds also infested by the Blister-beetles, it is very probable that the latter while in the larva state had fed upon the eggs of the locusts. This supposition appears to be rendered all the more probable by the further fact that in the immediate vicinity of these beetles the locusts did not occur in large numbers, nor had the orchards and vineyards in this locality been seriously injured by them. The fact recorded above that the larvæ of other species of Blister-beetles belonging to the same genus are known to feed upon the eggs of locusts renders it almost certain that the present species while in the larva state also feeds upon the eggs of these insects, and would, if sufficiently plentiful, keep the locusts so reduced in numbers that it would be impossible for them to become numerous enough to occasion any widespread injury to cultivated trees and plants. Unfortunately there appears to be no method whereby we can secure the more rapid propagation of these and the other natural enemies of the locusts, and our only recourse therefore is to subdue these pests by artificial means.

REMEDIES.

I have already stated the fact that when the locusts appeared in ordinary numbers they were effectually destroyed by the use of the bran and arsenic mixture, composed of the following ingredients in the proportions here given:

	Pounds.
Bran	100
Arsenic	16
Sugar	16
Water sufficient to thoroughly wet the mixture.	

The bran is placed in any convenient receptacle, and the arsenic added to it dry; the two are then thoroughly mixed together with a shovel, spade, or other instrument. The sugar is then dissolved in cold water and afterwards added to the bran and arsenic mixture and the whole thoroughly stirred; if this is not sufficient to wet the mixture, enough cold water should be added to accomplish this, and after being thoroughly stirred, the mixture is ready for use. In applying it, some persons sow it broadcast by hand in the orchards and vineyards, while others simply drop about a teaspoonful of the mixture at the base of each vine or tree. By the latter method about 10 pounds of the bran and $1\frac{3}{5}$ pounds each of sugar and arsenic will be required for each acre of grapevines. The cost of the materials and of the labor in preparing and applying this mixture will not much exceed 50 cents per acre of grapevines, while in the orchards the cost will be much lower than this.

The addition of the sugar is simply for the purpose of causing the arsenic to adhere to the particles of bran, and not for the purpose of rendering the mixture more attractive to the locusts, since I ascertained

by experiments that the bran is much more attractive to the locusts than sugar is. Some persons informed me that they had used molasses in place of the sugar, and with equally good results. A few had added a quantity of glycerin to the mixture in order to prevent it from drying out and forming a solid mass that the locusts can not readily feed upon, but it is doubtful if this is any great improvement over the ordinary way.

I met several persons who reported that they had not obtained satisfactory results by the use of this mixture, but I learned from them that they had used only 2 pounds of arsenic to 100 pounds of bran; this, of course, would make a very weak mixture, containing only one-eighth as much arsenic as it should have contained, and therefore it is not to be wondered at that it did not produce the same results as the stronger mixture would have done. The arsenic in this mixture is very slow in its actions upon the locusts. I have seen locusts feeding upon it quite early in the morning, and these were still alive in the evening, but died during the night.

There has been some objection made to the use of this mixture on account of the danger attending its use, but with only ordinary precautions no danger need be apprehended from it. Although it has been quite extensively used in various parts of this State during the last six years, still I have not learned of a single instance where human beings or domestic animals of any kind have been poisoned by it. It is advisable to prepare the mixture in a closed room in order to prevent the arsenic from being blown about by the wind, but after the mixture has once been thoroughly saturated with water there is no danger of its being blown about, nor is there any great danger of its being carried about upon the feet of birds or insects. Of course it should never be placed within the reach of poultry or of domestic animals of any kind; these, however, are seldom allowed to run in the orchards or vineyards, so that little or no additional trouble would result from the use of the poisoned mixture in such places.

Several persons informed me that they had sprayed their trees with Paris green and water at the rate of 1 pound of this poison to about 200 gallons of water, but this did not deter the locusts from feeding upon the leaves of the trees thus sprayed; nor could it be discovered that any of the locusts had been destroyed by feeding upon the poisoned leaves. This is scarcely to be wondered at, since it would not be possible in this manner to cause a sufficient quantity of the poison to adhere to the leaves without at the same time severely injuring the latter. A far better plan is to use the bran and arsenic mixture described above, as there is no danger of injuring the trees by its use.

I was also informed that trees had been sprayed with various substances to deter the locusts from feeding upon them, but all that I conversed with upon this subject reported unsatisfactory results. The following from the *Folsom Weekly Telegraph* of August 1, 1891, would

seem to indicate that at least one person had obtained good results in this direction:

A WAY TO FIGHT GRASSHOPPERS.

EDITOR TELEGRAPH: While on business at Capt. Russell's ranch, about 5 miles northeast of this place, in Placer County, I found his fine orchard and vineyard all safe from the ravages of the grasshopper pests, although they have played sad havoc with other orchards near by. Upon inquiry of the Captain I was informed that he had used a remedy that did not suit the tastes of the hoppers, and therefore they chose other localities in which to locate. He used the following preparation: One pound of aloes to 5 gallons of water. Dissolve well in warm water and then spray with a fine spray pump. A simple taste of this liquid seems to discourage the operator and he moves to other quarters. Capt. Russell thinks that his discovery is good when well applied. I give this information for what it is worth, and hope some good may be derived from it. The condition of Capt. Russell's orchard justifies the confidence he expresses in the remedy mentioned.

G. S. TONG.

FOLSOM, CAL., *July 28, 1891.*

The fact that the locusts feed upon such a great variety of trees and plants, including such offensive ones as tarweeds and Conifers, which most other leaf-eating insects pass by, would seem to indicate that it would be extremely difficult to find a substance so disagreeable and offensive to the locusts that they would not feed upon the leaves of plants sprinkled with it. It is possible that blood obtained from the slaughterhouses might answer this purpose, since it has been found that rabbits will not feed upon the bark of trees on which blood had been rubbed.

Quite a number of persons employed turkeys for the purpose of freeing their orchards and vineyards of the locusts, and I learn from one of the members of a certain firm in San Joaquin County that they employed a flock of 766 turkeys in their orchard, which contains about 800 acres of fruit trees of various kinds. One turkey will destroy an almost incredible number of locusts in a single day, and a flock of the size of the one above described must necessarily destroy large numbers of the pests in the course of an entire season. I was informed of several instances where turkeys had eaten too freely of the locusts, having partaken of them to such an extent as to result in the death of the turkeys, but it was asserted that this never happened if the turkeys had been fed grain before being turned into the orchard in the morning. Several persons objected to having the turkeys in their orchards owing to a fondness which these birds develop for ripe fruit, as it was found that when the turkeys once took to feeding upon the fruit they forgot all about the locusts and proved quite as great a pest as did the insects which they were expected to annihilate, rather than to aid, in their destructive work. Owing to this undesirable habit of the turkey it would be advisable to allow them the freedom only of nonbearing orchards and vineyards, or at least, of those not containing ripe or nearly ripe fruit.

Besides turkeys, the common barnyard fowls also prove to be very efficient destroyers of locusts. This fact was abundantly attested in the case of an almond orchard containing about 360 acres; this orchard had been attacked by the migrating swarms which had spread over the greater portion of it. The house, barn, and other buildings were situated nearly in the center of this orchard, and the barnyard fowls had been allowed to range among the trees immediately surrounding them; these trees covered perhaps 6 or 8 acres of land, and, at the time of my visit to this place on the 7th of August, presented a very different appearance from those in the remaining portion of the orchard, reminding one somewhat of an oasis in the desert. All about them the trees had been nearly stripped of their leaves by the voracious locusts, while upon those growing in the area designated above but few of the leaves upon the trees had been eaten, owing to the persistent attacks of the barnyard fowls upon the invading locusts.

In some localities the practice of driving the locusts out of the orchard was resorted to, and resulted in some cases in a fair degree of success. To accomplish this a band of men armed with clubs, shovels, etc., started in at the eastern side of the orchard, and forming a continuous line north and south, proceeded to drive the locusts before them, driving them from tree to tree until they were driven completely out of the orchard. It was stated that after the locusts had been driven a certain distance they refused to go any farther, as if too tired, but after being allowed to rest for a short time they then permitted themselves to be driven before the advancing line of men. This driving was repeated six or seven times at short intervals, and in the majority of cases resulted in preventing the locusts from defoliating the trees.

Some persons employed a somewhat different method of driving the locusts out of their orchards. A small pile of dry straw was placed on the west side of each tree in the orchard, and a small quantity of sulphur thrown upon each pile; the most eastern piles of straw were first ignited, and the wind, blowing from the west, blew the sulphur smoke through the trees standing to the eastward of the burning straw; this caused the locusts to fly out of these trees, and as they always go almost straight against the wind, they would fly to the trees in the rows west of those they were smoked out of. The next row of straw piles was then set on fire, and this process was continued until the locusts had been driven entirely out of the orchard. In conversation with several persons who had tried this method I was informed that it resulted in a fair degree of success, while several others, who had also tried it, informed me that it was a complete failure, and that the locusts paid no heed whatever to the sulphur smoke.

The practice of driving the locusts out of one orchard into another can hardly be approved upon general principles, as it is hardly fair for any man to drive the pests out of his own orchard into that of a neighbor.

In the opening paragraph of the present chapter occurs the state-

ment that the locusts could be effectually destroyed by the use of the bran and arsenic mixture when they occurred in ordinary numbers, but I was informed that where they came in large swarms this mixture scarcely produced any appreciable effect in lessening their numbers, dozens of individuals coming to take the place of each of their fallen comrades, and these new comers succeeded in almost completely defoliating the trees in spite of the presence of the poisonous mixture. Unfortunately, I had no opportunity of testing this matter myself and therefore am unable to decide in regard to the truthfulness of this statement from personal experience.

Much might be accomplished in the matter of preventing the appearance in the cultivated orchards of the migrating swarms by destroying either the eggs or the young locusts in their natural breeding grounds. In a previous chapter I have given my reasons for believing that the swarms of locusts that occasionally appear in portions of the San Joaquin and Sacramento Valleys hatch out in the pasture lands among the foothills along the western base of the Sierra Nevada Mountains, in land overgrown with tarweeds. The eggs in these breeding grounds might be destroyed either by burning over these grounds late in the autumn after all of the eggs are laid, or by plowing under the eggs to a depth of 6 or 8 inches at any time before they hatch out in the spring. The eggs of the migrating California locust have never been seen by me, but there is every reason for believing that they are deposited in the same manner as those of other species belonging to the same genus. These are deposited in a mass, the upper part of which is nearly on a level with the surface of the ground, while the lower part is within three-quarters of an inch of the surface. It is very probable, therefore, that where there is any considerable quantity of dry weeds and other litter scattered over the breeding ground, by setting fire to this litter the heat generated from it would be sufficient to destroy all of the eggs existing in the ground thus burned over.

Instead of thus destroying the eggs it might be advisable to wait until the young locusts have hatched out in the following spring, and then destroy these young ones before they have acquired wings and migrated from the breeding grounds. This could evidently be accomplished with the least trouble and expense by scattering the bran and arsenic mixture over the breeding grounds shortly after the young locusts first make their appearance. In case that these breeding grounds occur in pasture lands it might be advisable to fence them in, so as to prevent the stock from being poisoned by this mixture put out for the locusts. I am not aware that stock of any kind will feed upon the tarweeds, so that but little loss in pasturage would be experienced if the stock were to be prevented from ranging over patches of them. I have been credibly informed that this method of poisoning the young locusts in their natural breeding grounds has been practiced in Fresno County for several years past, and that since it was first adopted no serious outbreaks of locusts have occurred in that county.

The fact as above stated that the Devastating Locust breeds only or almost wholly in places overgrown with tarweeds would indicate that if these weeds were destroyed by being plowed under, and later by thoroughly cultivating the soil, so that those appearing afterward would be destroyed, the locusts would no longer choose such places for oviposition; and just in proportion as this practice was extended, in the same proportion would there be a less number of the locusts produced in the localities operated in. And if it were possible to wholly eradicate these patches of tarweeds, that would evidently settle the question of locust ravages in that section of country for all time to come. Not only should the tarweeds in the pasture lands among the foothills be destroyed, but also those growing along the roadsides and in waste places about cultivated fields, since the locusts which hatch out in such places aid in no small degree the devastating work of the migrating swarms. Too much stress can not be laid upon this subject of preventing, as far as possible, the breeding of the locusts, and of destroying the young ones before they acquire wings. It has been the unfortunate experience of many of our orchardists in the region of country subject to these locust invasions, that after once the locusts have acquired wings and come into the orchards in immense swarms, one following the other, little or no headway can be made against them; our greatest efforts, therefore, should be directed against these pests before this stage of their existence is reached, and while it is still within our power to successfully cope with them. In this respect, an ounce of prevention is worth many pounds of cure.

In the case of small trees these can be protected from the ravages ot the locusts by being covered with sacks of cloth or of paper, allowing these to remain upon the trees until all of the locusts have passed away. For this purpose common barley or gunny bags, oat-meal sacks, and paper sacks of various kinds have been used. These were simply slipped over the young trees from above and the mouth of the sack tied about the trunk of the tree. In place of sacks some persons employed old newspapers, which they wrapped around the trees and fastened with strings. I saw several hundred young orange, prune, and various other kinds of deciduous trees which were inclosed in barley sacks, and I was informed that the sacks had been on the trees for over five weeks, still when several of them were removed the trees appeared to be as healthy and vigorous as any I ever saw. It was reported that a large number of trees had been killed by thus being covered with sacks, but I was unable to find a single case where this had occurred. The following paragraph on this subject is from the *California Fruit Grower*, of San Francisco:

> During the recent grasshopper invasion A. J. Lloyd, who has an orange orchard near town, covered his young trees with gunny sacks, to prevent damage, as reported by the Oroville Mercury. The effect has been most disastrous, for upon removing the sacks it was found that about 900 trees had been killed.

One orchardist who had used barley sacks successfully for the purpose of protecting his young orange and prune trees from the attacks of the locusts, informed me that some of his neighbors had used paper sacks with the result of killing the trees, but I was unable to ascertain how much truth there was in this assertion. I saw quite a large number of prune and olive trees that were wrapped in papers which I was informed had been on the trees for three or four weeks, but these trees had not been injured in the least by this treatment. A lady owning an orchard of young fruit trees near Pasadena found that the leaves of several of the trees had been eaten by a kind of May-beetle, *Serica fimbriata* Lec., which remained hidden from sight in the daytime and came forth only at night to feed upon the leaves. Having been applied to for advice I recommended that the trees be inclosed in barley sacks, and that they be allowed to remain upon the trees for a period of about three weeks, or until the May-beetles had passed away. Accordingly this was done, and during a recent visit to this orchard I found that the sacks had been duly removed and the trees were now growing vigorously, being to all appearances none the worse for their temporary imprisonment. This would at once disprove the assertion that trees are injured by being confined in sacks of this kind.

Of course, this method could only be employed for the protection of small trees; on large trees it would be altogether too expensive.

REPORT OF A TRIP TO KANSAS TO INVESTIGATE REPORTED DAMAGES FROM GRASSHOPPERS.*

By HERBERT OSBORN, *Special Agent.*

LETTER OF SUBMITTAL.

AMES, IOWA, *August 19, 1891.*

SIR: I beg to submit herewith my report of a trip, made in accordance with instructions received July 24, 1891, to investigate reported damages by grasshoppers in Kansas during the current year.

Very respectfully,

HERBERT OSBORN.

Prof. C. V. RILEY,
U. S. Entomologist.

In accordance with instructions received July 24, to visit and report on grasshopper injury in western Kansas, I started the following morning for Kansas and improved every opportunity on the way to learn of grasshopper injury. At Des Moines, where I waited a few hours for the Kansas City train, I went through a large number of Kansas papers, kindly placed at my service in the office of the *State Register* and *Iowa Homestead*, without, however, getting any information except assertions in some places that there were no hoppers in Kansas.

From a gentleman lately through Arizona I learned of the appearance of considerable numbers in that Territory and the expectation that these might be traveling eastward. At Kansas City I was equally unsuccessful, the only information received there being the statement of railroad men as to the occurrence of hoppers on the railroad in Colorado (the case investigated by Professors Snow and Popenoe), and of some in Arizona, along the line of the Atchison, Topeka and Santa Fé Railroad.

At Topeka I went first to the office of the State Board of Agriculture. The Secretary, Mr. Mohler, was absent, but the gentlemen present, Messrs. Longshore and Nyswander, kindly gave me a full statement as to the information the office contained.

They receive reports from over six hundred correspondents who are scattered over the entire State, the western portion being well repre-

* Reprinted from INSECT LIFE, vol. IV, p. 49.

sented. They assured me that not a single report had been received by them which mentioned injury from grasshoppers, and they were positive that no damage was being done.

At the newspaper offices I received similar replies, except that in the office of the *Kansas Democrat* I learned of a report that some damage had been done in Kearney County. As this report, however, was somewhat indefinite, I hesitated to make it the basis of a special trip to the extreme southwest part of the State, and, Lawrence being so near at hand, I concluded to go there to see if Professor Snow had any recent information.

Professor Snow was absent, but his assistant, Mr. V. L. Kellogg, kindly gave me all the information he could. He said that they had heard nothing from the region that had been examined by Professors Snow and Popenoe in Colorado, except that the winged insects were moving south, and he was sure that none of these had entered Kansas.

He also informed me that they had received information of injuries at Garden City, and showed me specimens of *Caloptenus differentialis* and *bivittatus* received from there.

This information tending to substantiate the report of damage in Kearney County, I decided to visit Garden City and took the first train for that place. On the way I kept careful outlook for any signs of damage, and improved the opportunity of occasional stops to collect specimens and inquire of residents as to the prevalence of grasshoppers. All answers agreed in denial of any unusual numbers of grasshoppers or of injury from them, and it was not till I reached Garden City that I learned of any damage. Here I was told that the alfalfa fields were being ruined, and it was only a short time after my arrival that I was in a field a mile from town where the conditions showed at once the state of affairs to be serious.

The alfalfa was badly stripped, the blossoms and seed entirely eaten up, and in many patches the stems were stripped bare of leaves, looking brown and dead.

The grasshoppers, mostly *differentialis*, with a considerable number of *bivittatus*, when rising in front of me as I walked through the field, formed a cloud 8 or 10 feet high and so dense as to hide objects beyond them. Here I noticed a number of grasshoppers dead from the attacks of parasitic Tachinids.

From this field I went to another, owned by the same man, which was also well filled with grasshoppers, but the injury here was less, especially around the buildings, where a large number of turkeys were doing excellent service in killing the hoppers and at the same time adding rapidly to their own weight.

In a field of sorghum directly adjoining there was also considerable injury, but *differentialis* seemed scarce, while a bright green species, *Acridium frontalis* Thos., was abundant and apparently the principal agent of destruction. This species was also noticed here and in other

places occurring in great abundance on the Wild Sunflower so common on these plains, and the question arose whether this was not its natural food plant and its attacks on sorghum incidental.

The day following I spent the forenoon with Dr. Sabin, who kindly furnished a horse and cart and accompanied me in examining a number of farms within 5 miles of Garden City, where alfalfa fields and orchards were injured. I met and talked with a number of farmers who had suffered from grasshopper depredations, and the information received from them with what I gained by personal observation satisfied me that losses could be avoided by proper measures.

I learned that the same injuries extended farther west along the river where alfalfa was grown, and I proceeded from Garden City to Lakin, observing on the way that all alfalfa fields showed presence of grasshoppers, but that in some cases the bloom was still free from serious injury or destroyed only in patches. At Lakin I learned that injury had been serious, especially on the place of Mr. Longstreth, some two miles from town. Some fields near the river and occupying low land were noticed in full bloom and showing little damage, but still grasshoppers could be found in abundance by closer inspection of the fields.

Mr. Longstreth's son, being in town, drove me out to his father's farm, and accompanied me on a tour through his extensive orchard of 10 acres, his oat field and alfalfa fields, in all of which the damage had been serious. Many of the trees in the orchard were entirely stripped of leaves, and in some cases the bark had been eaten from the limbs. The alfalfa presented the same appearance as observed in other fields. I found here a great many dead grasshoppers, whose empty shells attested the activity of Tachinæ.

I was told by Mr. Longstreth that skunks were amongst the most active enemies of the grasshoppers, and he believed played an important part in reducing them. He had even seen one up in an apple tree catching hoppers on the limbs.

I learned at Lakin that alfalfa was also grown in the next county west, at Syracuse, and that damage was also reported there, but on reaching the place found the injury slight as compared with the other places visited. In fact, aside from one farm on which some damage to alfalfa and orchard had occurred I could learn of no loss. *Caloptenus differentialis* I found in some numbers, and there is little doubt that unless some effort is made this fall and next spring to destroy eggs and young they will multiply as in other localities, and probably by next season prove as destructive as in them.

As this point carried me into the westernmost row of counties in the State, and there was no report of damage farther on, I determined to cross northward to the Missouri Pacific Road, in order to follow up some rumors regarding damage from grasshoppers at some points intervening, and which, from the descriptions given, seemed possibly to be due to *Dissosteira longipennis*. No point where serious loss occurred was found, however, and this species occurred but sparingly at points between

Syracuse and Tribune, and occurred at Horace only in small numbers, too few to cause any apprehension for the immediate future at least. Taking the Missouri Pacific, I passed through to Kansas City without finding any evidence of damage from grasshoppers, and as I could learn of no other localities in the State than in the three counties examined where such damage was reported, I returned to Ames, and will now proceed to a detailed account of the territory examined, the species observed, and the special measures needed to meet the outbreak in this section.

THE TERRITORY AFFECTED.

The damaged territory is quite easily defined and might very properly be said to coincide with the irrigated portion of the Arkansas Valley lying in Finney, Kearney, and Hamilton counties in southwest Kansas. The entire irrigated district, however, is not equally injured and there are some fields much less damaged than others. The whole area covered extends with occasional breaks a distance of about 50 miles along the river and forms a strip from 1 to 5 miles wide but limited entirely to areas where irrigation has been practiced, and within this limit is dependent upon the kind of crops raised.

The greater damage was observed at Garden City, though nearly as bad was seen at Lakin, and but little was found at Syracuse, corresponding as near as I could learn pretty closely with the length of time since alfalfa has been made a principal crop on the irrigated lands.

THE CROPS AFFECTED.

Alfalfa is the crop in which there is the most loss, but orchards are suffering badly, and were they extensive throughout the district would very probably present the heavier loss.

The alfalfa crop is a very profitable one and easily grown with irrigation, and has been very extensively planted, the fields devoted to it covering many thousands of acres.

The injury to this crop is of such a nature that I believe practical remedies may be adopted, and, as will be stated later, active measures should be adopted this fall and next spring.

THE AMOUNT OF INJURY.

The great loss this year has resulted from the destruction of the seed crop. In many fields this has been a total failure, and the loss may be considered as covering thousands of acres and involving many thousands of dollars. One man who had something over 100 acres in alfalfa considered that his loss amounted to about $2,000. While he expected to cut and use the crop for hay, the damage had been such that the hay would be little better than after the seed crop had been secured, and he reckoned the full loss of the seed crop for the season. In some cases

farmers were cutting for hay when they had intended to allow the crop to go to seed, and in this way were reducing the amount of their loss by the value of the crop of hay cut early over what the hay would be worth after maturing seed, the latter, of course, being much less valuable than the hay cut before seed matures. In many cases the farmers had been depending largely upon the crop of seed to help them out of debt, and the loss from the grasshopper injury falls heavily upon them.

THE SPECIES DOING THE DAMAGE.

The Differential Locust is, I think, chargeable with fully nine-tenths of the destruction, both in alfalfa and orchards, and the reasons for its increase in this section seem to me quite evident. The irrigated fields of alfalfa furnish it with favorite food in abundance throughout the year and have given it an opportunity to multiply rapidly without exhausting its food supply.

The ditches which traverse the fields and possibly parts of the fields themselves furnish a most excellent location for the deposition of eggs, the ground being compact and for the most part undisturbed throughout the year. That the eggs are deposited in or alongside the ditches is indicated by several facts, though at the time of my visit the locusts, while pairing, were none of them ovipositing. In the first place, the greatest damage has occurred in strips on either side of the ditches, and only in the worst fields extends over the entire field; second, at the time of my visit the pairing individuals were quite evidently collecting more particularly in these locations; third, the testimony of those who seemed to have observed most closely agreed in placing the greatest number of young hoppers in spring along the borders of the ditches, a point which is clearly supported by the injured strips so plainly to be seen. No one whom I questioned had seen the locusts in the act of ovipositing.

The ditches contain no water during a large part of the year, and in fall the compact bottom, which doubtless affords more moisture than the fields in general, would seem an excellent place for the deposition of eggs, as well as the banks on either side. Judging by the habits of these and allied species in other locations it would be hard to conceive a more favorable place for the deposition of eggs, and it seems to me very probable that this, as well as the suitability and abundance of the food, may be considered an important factor in the rapid increase of the species in the last three or four years, an increase that has taken place directly with the cultivation of alfalfa by irrigation.

It would seem also that this habit renders the insect especially open to attack, and I see no reason why concentrated effort may not entirely prevent a repetition of the damage another year.

MEASURES RECOMMENDED.

The situation, it seems to me, is one deserving serious attention, but

one which offers every hope for successful work, if the residents of the affected localities can but be induced to make a little effort at the proper time.

The means which appear to me from inspection of the ground to promise most successful results would be as follows:

(1) To thoroughly break up the surface of the ground in and along the ditches before winter by harrowing thoroughly, cultivating or shallow plowing, thus exposing the eggs to winter weather and natural enemies.

(2) Wherever practicable, to flood the ground for a day or two at the time young locusts are hatching. I was told that the young hoppers were entirely unaffected by water, as they would crawl up the alfalfa stems and escape, and it is probable that sufficient flooding to accomplish much good in this region is out of the question. My only hope in this line would be in watching carefully for the time of hatching, and using the water before the hoppers had obtained any growth, and if abundant along the ditches, putting a little kerosene on the water.

(3) A use of the hopperdozer as early in the season as possible, when I believe the treatment of a strip 8 or 10 feet wide on each side of the ditches would destroy so large a part of their numbers as to prevent any serious damage. As I learned from a number of parties the hoppers are scarcely half grown when the first crop is cut, it would seem that immediately after cutting the first crop would be the best time to use the hopperdozer. The hoppers would be large enough to jump readily and the dozers could be run very easily. It would be difficult to use them at any other time than directly after a crop was cut, as the dense growth of alfalfa would obstruct their movement.

My strongest recommendation would be the urging of effort in breaking up egg masses before winter, and then in case locusts still appear in any number in spring to resort to the dozers at first opportunity. I believe active use of these measures will be effectual, with a cost but trifling compared with the value of the crop to be saved.

The information as to the species and the measures needed are covered very fully in your Bulletin on Destructive Locusts,* and with some specific instruction regarding the treatment of ditches in this special locality would, I think, give the people of the district affected all the information necessary to protect themselves, and it would seem advisable to send a number of copies of that bulletin to the postmasters at Garden City, Lakin, and Syracuse, to distribute to farmers, who would make use of them, as well as to those whose names I will furnish for this purpose.

OTHER SPECIES OBSERVED.

The species next to *differentialis* that I should call most abundant in the injured fields was *bivittatus;* but taken alone its damage would

* Bull. 25, Div. of Entomology, U. S. Dept. Agriculture.

have been insignificant. Its habits are so nearly like those of *differentialis* that I see no occasion to give it further mention, and I have little doubt that any measures adopted against *differentialis* will prove as effective against this species.

Dissosteira longipennis was taken in some numbers at all points visited in Finney, Kearney, Hamilton, and Greeley counties, and as this species has caused so much injury in eastern Colorado this season, I took rather special pains to note its abundance and inquire as to any destruction resulting from it. At no point did it occur in destructive numbers, and I should not look for any injury from it in these localities in the near future at least.

PARASITES AND DISEASES.

The many parasitized grasshoppers noted indicated a multiplication of such forms, and these will undoubtedly accomplish much in reducing the numbers that can deposit eggs this fall, but I should deem it unwise to depend on them and to omit the active measures already urged.

The most general parasites were apparently the Tachina flies, as the great majority of dead hoppers were found to be completely devoured within.

Some of the dead grasshoppers had the appearance of having been affected with Entomoyhthora, and I gathered a number in order to make an effort to cultivate the disease, but as yet have nothing to report in this line. The dead hoppers will be kept with living ones, and if the latter take the disease we may hope to still further multiply the disease by inoculating still others, and then an effort can be made to distribute the disease in the fields. Its spread, however, is evidently slow, and I do not think other measures should be neglected this season for a plan which is still uncertain.

Among the natural enemies observed, toads were perhaps the most common, some of the fields containing great numbers of them, especially of half-grown individuals, and these would seem capable of greatly reducing the number of hoppers. A dead one, which saved me the necessity of making a dissection to get positive proof, showed in the partly decomposed stomach the legs and other parts of grasshoppers, proving that, as would be inferred from presence of toads in the fields, their mission was to feed upon the grasshoppers.

The attacks of skunks upon grasshoppers, as stated by Mr. Longstreth, have already been mentioned.

As the tendency is for natural enemies to multiply with the increase of any species of insect, we may look for increased assistance from this source by another year, and in connection with the measures already urged, these ought by another year to keep the insect entirely within the limits of destructiveness.